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Procedia Computer Science 89 (2016) 651 – 657

Procedia Computer Science

Twelfth International Multi-Conference on Information Processing-2016 (IMCIP-2016)

Blood Cell Detection using Thresholding Estimation Based Watershed Transformation with Sobel Filter in Frequency Domain

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Abstract

Blood cells detection in microscopic image provides the information concerning the health of patient. The analysis of blood cells using image processing reduces the manual disease detection error and also the time period. A new thresholding estimation algorithm has been proposed with watershed transforming Sobel filter in frequency domain for detection of different cells in microscopic image. The proposed algorithm performs edge detection using Sobel filter in frequency domain. The present study of Sobel filter uses specific window size scheme to remove noises and detect the fine edges. Consequently, thresholding estimation based watershed transformation is used on the specific window size Sobel filter to increase the intensity of edges with strong contrast. Thus this effective detection algorithm is helpful to identifying and counting the different cells. In this study, proposed algorithm has used 30 numbers of blood microscopic images as test images and obtained higher accuracy results of around 93%. Experimentally, the proposed algorithm yields better structure similarity index measure, compared with the other state-of-art detection method viz. Canny, Sobel and Laplacian operator.

Keywords: Blood Cell; Threshold; Microscopic Blood Image; Sobel Filter; Watershed Transformation.

1. Introduction

The processing and analysis of microscopic image is a broad field in research area. There are more than 4,000 kind of different components in blood. White Blood Cells (WBC), Red Blood Cells (RBC), Platelets and Plasma are four important constituents. Identifying the different blood cells helps to find out disease detected cells. It is difficult task to identifying and counting the blood cells manually which is carried out by human observation in laboratory. Approaching a new automated blood cell detection algorithm reduce the detecting time and produce accurate results.

Segmentation over an image is performed to detect the required information in image analysis. Blood image segmenting method is used to build the separation between the cells and proper detection of different blood cells. This image processing technique of blood cell detection can also be used for different disease detection by analyzing the each cell accurately. There are different segmentation algorithms which are taken into consideration for detection like rule based strategies[1], Ostu method[2] and thresholding method[3] etc. H. Harms *et al.*[4] has discussed an algorithm

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doi:10.1016/j.procs.2016.06.029

for extraction, detection and counting the cells. An algorithm was proposed for WBC segmentation using watershed color space clustering and nucleus filtering by Jiang *et al.*[5]. Due to the high density of cells, the segmentation and counting of WBC is much more difficult. In[6], authors described a structure of WBC segmentation using digital image processing. Proper cell detection also means by the border detection of segmented cells, was proposed by Ritter *et al.*[7]. Watershed algorithm also used for the segmentation of touching cells but often results over segmentation. Addressing the problem, this paper has introduced a new approach of blood cell detection using threshold estimation based watershed transformation with sobel filter in frequency domain. Mandeep *et al.*[8] also proposed and developed, an algorithm using marker controlled watershed to detect the white blood cells. Consequently, analyzing the detection of blood cells using the proposed method presented in this paper has also obtained higher accuracy results.

2. Related to Work

2.1 Pre-processing

Pre-processing of an image is to convert the RGB image into gray scale. A weighted average of three different color components i.e., red, green and blue values are converted to equivalent gray scale values. The function of input image $f(a, b)$, where a and b are the dimensions with x axis and y axis coordinates. The weighted gray scale average value is represented by Y_{gray} in equation (1).

$$f_{\text{gray}} = 0.29R + 0.59G + 0.11B \tag{1}$$

The gray scale image function is $I(a, b)$ is the computed output of $f(a, b)$. Fig. 1 shows the conversion of a blood slide image.

2.2 Image segmentation

In image processing and vision computing, the separation of homogenous area in different regions is known as image segmentation[9–11]. The analysis of different blood cells helps to identify the human diseases. Counting the different cell, shapes measurement and abnormal cell detection in blood slide images is a key part of blood cell segmentation. Automated detection using image processing is less time consuming and error free than manual detection. Main objective of the blood cell segmentation is border detection or boundary detection of cells. These region based information about the cells are incorporate for the further process.

2.3 Thresholding based watershed transforming

A method of image segmentation was proposed for segmentation of WBC by Lim Huey Nee *et al.*[12]. Authors have used watershed transformation to separate the touching cells. This transformation follows 8-neighborhood concept and identify the input matrix regions. Thresholding estimation process is applied over the transformed image to overcome the watershed transformation problem.

$$X(a, b) = WT\{I'(a, b)^T\} \tag{2}$$

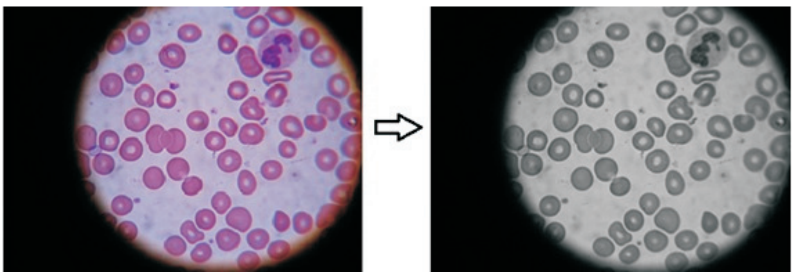


Fig. 1. RGB to Gray Scale Converted $I(a, b)$ Blood Cell Image.

where, $I'(a,b)$ represent the filtered image function with gradient magnitude and $X(a,b)$ represent the watershed transformed output. The visualization of the image in three dimension of (a,b) coordinates and intensity c axis. In equation (2), transformation image output is depends on the intensity of the pixels. More intensity may cause the inappropriate separation of the cells and results segmentation error. To set this problem thresholding estimation method is used. The intensity of the pixels is set to a certain thresholding value 'T' for the appropriate separation of the cells in blood images. Automated selection of the 'T' is implanted each time for different blood cell images by measuring the mean of intensity values using equation (3). Thus, the simulation results using thresholding based watershed are more appropriate than the simple watershed transformation.

$$T = \frac{\sum_{a=1}^{i} \sum_{b=1}^{j} I'(a,b)}{i \times j} \tag{3}$$

where, i and j are height and width of image.

2.4 Frequency domain

The main principle of frequency domain filtering is to manipulating the transform coefficients. An image can be consists with two different type of frequency component known as high frequency component and low frequency component[13]. According to these frequency components the images are processed in frequency domain technique. The filtering concept in frequency domain is easier to visualize. There are some basic steps to filtering in frequency domain are[14]:

1) Using the FFT an image is transformed from spatial domain to frequency domain.
2) Resulting image is multiplied by a filter.
3) Filtered image is transformed back to spatial domain.

An advantage of frequency domain filtering is to enhancement the quality of the input image.

3. Proposed Work

This paper presents a proposed method of blood cell detection to improve the computational process of cell detection and develop the detection process of computer vision based system. The proposed segmentation approach uses the following step to detect the blood cells:

1) Conversion of RGB to grayscale image.
2) Apply the Sobel filter in frequency domain to detect the boundary of each cell.
3) Calculating the threshold value T iteratively.
4) The value of T is applied on the Watershed transforming image for segmentation.

The block diagram of the proposed segmentation method is shown in Fig. 2.

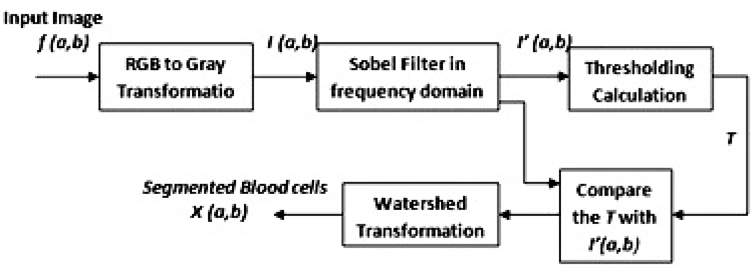


Fig. 2. Block Diagram of the Proposed Method.

3.1 Sobel filter in frequency domain

Sobel filter in frequency domain is describing the function of gradients both in horizontal and vertical directions. Separate mask is created for gradient image to find the edges and applying frequency domain filtering techniques to enhance the quality of filtered image. A 3×3 mask is created for both horizontal and vertical position to multiply with gradient image. The following are the steps of filtering:

1) If the gradients are large than the edges occur.
2) Horizontal mask and vertical mask are generated for both the directions of input image.

$$I_{\text{ver}}\ (a, b) = \begin{matrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{matrix} \quad I_{\text{hori}}(a, b) = \begin{matrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & 2 & -1 \end{matrix}$$

3) Gradient magnitude can be calculated by equation (4).

$$g = \sqrt{|g_a|^2 + |g_b|^2} \tag{4}$$

4) Fourier transformation of image and sobel filter both. Then multiply it point by point, i.e., in frequency domain.

3.2 Thresholding estimation

Steps for the thresholding estimation are:

1) Initialize the value of 'T' which is equal to the value of average intensity of filtered gradient image $I'(a, b)$ as defined in equation (2).
2) Initially iteration index $k = 0$, to separate the $I'(a, b)$ into two classes. If T^k is greater than gradient values than lower classes consist of those pixels of $I'(a, b)$ and higher classes consists rest all.
3) Calculate the average values of two different class's gradient i.e., C_L and C_H, lower class and higher class respectively.
4) Now, set the iteration $k = k + 1$. Then the threshold value:

$$T^k = \frac{C_L + C_H}{2} \tag{5}$$

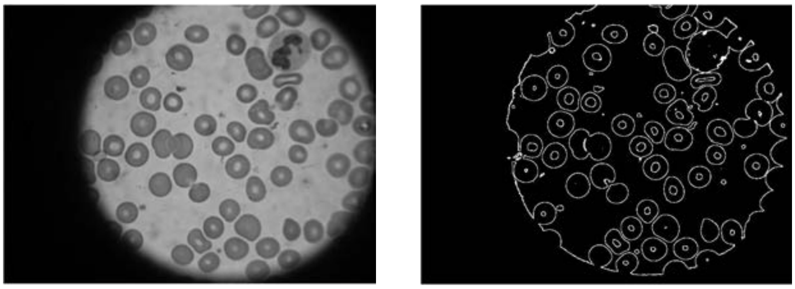
5) $|T^k - T^{k-1}| \leq \in$, where $\in \to 0$; and T^k is threshold value. If not then the process will repeat from step 2 to step 4.

4. Simulation Results and Discussions

In this paper, a new algorithm is proposed and microscopic blood images are taken for the algorithm to detect the blood cells. Sobel filter in frequency domain and watershed segmentation based on thresholding estimation method is used to process the algorithm to identifying the different cells in the microscopic blood image. Simulation results of microscopic blood image using the proposed method are shown in Fig. 3 and Fig. 4.

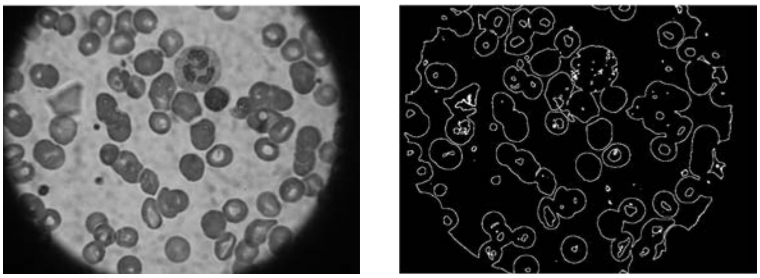
It is clearly observed that the proposed method is better to detect the cells and easily it possible to distinguishes between the different cells. In Fig. 3(a) and Fig. 4(b) different test input images are considered from the database. The simulation results using the proposed method is shown in Fig. 3(b) and Fig. 4(b) for the test input image_1 and test input image_2, respectively.

Total 30 numbers of microscopic blood images are considered to evaluate the performance of the proposed method. The visualization of the simulation output is better using the presented method. Also the statistical calculations of the simulation results are considered to find the superiority of the proposed method. For quantitative evaluation, Structure Similarity Index Matrix (SSIM)[15] is calculated using equation (6) and compared with other methods like canny, Sobel and Laplacian operator. The comparison of average SSIM by taking the 30 numbers of microscopic images is drawn



(a) (b)

Fig. 3. (a) Microscopic Blood Test Input Images_1 in Gray Scale (b) Blood Cells Detection using Proposed Method.



(a) (b)

Fig. 4. (a) Microscopic Blood Test Input Images_2 in Gray Scale (b) Blood Cells Detection using Proposed Method.

Table 1. SSIM Calculation and Comparison.

Sl. No.	Detection Method	SSIM
1	Canny method	0.8734
2	Sobel method	0.9056
3	Laplacian operator	0.9165
4	Proposed method	0.9879

in Table 2 using the equation (7). Higher SSIM values suggested better simulation results of blood cell detection from microscopic blood images.

$$\text{SSIM}\ (I, K) = \frac{(2\mu_I\mu_X)(2\sigma_{IX} + c_2)}{(\mu_I^2 + \mu_X^2 + c_1)(\mu_I^2 + \mu_X^2 + c_2)} \tag{6}$$

$$\text{Avrg.SSIM}\ (I, K) = \frac{\text{SSIM}\ (I, K)}{N} \tag{7}$$

In equation (7), $N = 30$ i.e., total number of test images. The Graphical simulation results of SSIM are shown in Fig. 5.

A graphical view of different 30 numbers of microscopic blood images are plotted and conclude that outperforms of the proposed method is better than the other detection methods as the SSIM values are higher. The simulation result clearly depicts different type of WBC cells like neutrophil, eosinophil and lymphocyte from the output blood cells detected images. Different extracted blood cells are shown in Fig. 6.

Comparison of simulation output results of different methods like canny, laplacian, sobel and proposed algorithm are shown in Fig. 7. The outcome images by proposed method are better than other methods to distinguish between different blood cells in microscopic images.

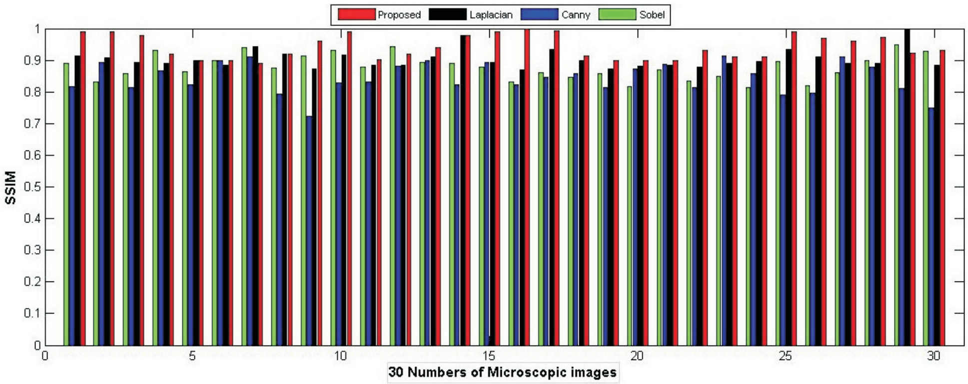


Fig. 5. Graphical Representation of Structural Similarity Index Matrix (SSIM) of 30 Numbers of Microscopic Images for Various Detection Methods.

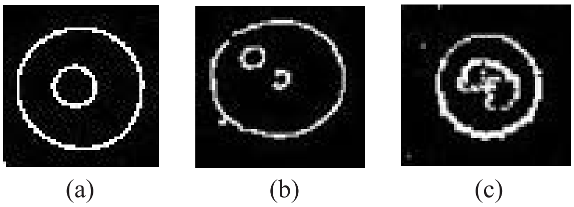


Fig. 6. Extracted Cells from Microscopic Blood Images. (a) RBC, (b) Eosinophil, (c) Monocyte.

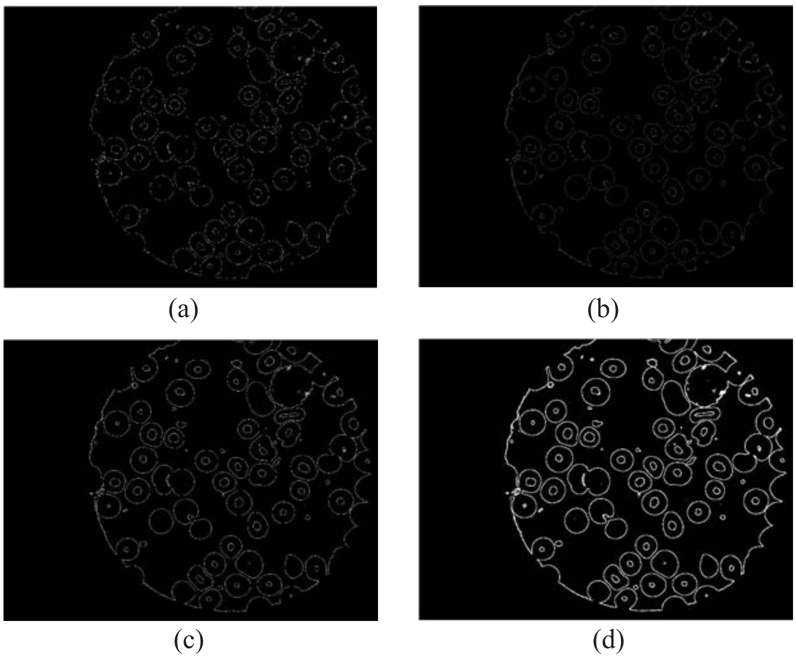


Fig. 7. Simulation Results of Various Detection Method (a) Canny Method, (b) Laplacian Operator Method, (c) Sobel Method, (d) Proposed Method.

Table 2. Accuracy Measure and Comparison.

Algorithm	Accuracy (%)
Canny Method	79
Sobel Method	82
Laplacian Operator Method	81
Proposed Method	93

Proposed algorithm also provides higher accuracy results with 30 number of microscopic blood images shown in Table 2.

5. Conclusions

The proposed algorithm was tested over various microscopic images. WBC and RBC are the most dominant features in blood images, where WBCs are classified into five different types. This proposed method was successfully detected the cells with higher similarity index matrix (SSIM). The comparison with other detection methods concludes the superiority of the proposed algorithm and around 93% accuracy was found with 30 numbers of microscopic blood images. In future, increasing the number of test microscopic blood images may be included to support the proposed algorithm and further process the images to identify the infected cells in order to detect the human diseases.

References

[1] C. Wahlby, J. Lindblad and M. Vondrus *et al.* Algorithms for Cytoplasm Segmentation of Fluorenscence Labeled Cells, *Anal. Cell. Pathol.*, vol. 24, pp. 101–111, (2002).
[2] Hima Bindu, An Improved Medical Image Segmentation Algorithm using Otsu Method, *International Journal of Recent Trends in Engineering*, vol. 2, no. 3, pp. 88–90, (2009).
[3] Gonzalez, Rafael C. & Woods and E. Richard, Thresholding, in Digital Image Processing, Pearson Education. ISBN 81-7808-629-8, pp. 595–611, (2002).
[4] H. Harms, H. Aus, M. Haucke and U. Gunzer, Segmentation of Stained Blood Cell Images Measured at High Scanning Density with High Magnification and High Numerical Aperture Optics, Cytometry, vol. 7, pp. 522–531, (1986).
[5] Kan Jiang, Qing-Min Liao and Sheng-Yang Dai, A Novel White Blood Cell Segmentation Scheme using Scale-space Filtering and Watershed Clustering, *International Conference on Machine Learning and Cybernetics*, pp. 2820–2825, (2003).
[6] Farnoosh Sadeghian, Zainina Seman, Abdul Rahman Ramli, Badrul Hisham Abdul Kahar and M-Iqbal Saripan, A Framework for White Blood Cell Segmentation in Microscopic Blood Images using Digital Image Processing, springerlink.com. Biological Procedures Online, vol. 11, no. 1, (2009).
[7] N. Ritter and J. Cooper, Segmentation and Border Identification of Cells in Images of Peripheral Blood Smear Slides, In *Proceedings of the Thirtieth Australasian Conference on Computer Science*, vol. 62, pp. 161–169, (2007).
[8] Mandeep Kaur and Gagandeep Jindal, Medical Image Segmentation using Marker Controlled Watershed Transformation, *International Journal of Computer Science and Technology*, vol. 2, no. 4, pp. 548–551, (2011).
[9] Rafel C. Gonzalez and Richard E. Woods, Digital Image Processing, Pearson Education, Inc., (2009).
[10] S. Jayaram, S. Esakkirajan and T. Veerakumar, Digital Image Processing, Tata McGraw Hill Education Private Limited, (2009).
[11] Xin Qi, Fuyong Xing, David J. Foran and Lin Yang, Robust Segmentation of Overlapping Cells in Histopathology Specimens using Parallel Seed Detection and Repulsive Level Set, *IEEE Transaction on Biomedical Engineering*, vol. 59, no. 3, pp. 754–765, (2012).
[12] Lim, Huey Nee, MohdYusoff Mashor and Rosline Hassan, White Blood Cell Segmentation for Acute Leukemia Bone Marrow Images, In *2012 International Conference on Biomedical Engineering (ICoBE)*, IEEE, pp. 357–361, (2012).
[13] Annadurai, Book Chapter.
[14] Samanthapurivijay, Image Enhancement using Frequency Domain Filtering, Electronics and Communication CMR technical Campus, Hyderabad, India.
[15] Lin Zhang, Lei Zhang, Xuanqin Mou and David Zhang, FSIM: A Feature Similarity Index for Image Qualtiy Assessment, *IEEE Transactions on Image Processing*, vol. 20, no. 8, pp. 2378–2386, (2011).