A Similarity of Sobel And Prewitt Edge Detection for Cell Counting Simulation Of Human Blood Cells Using MATLAB

M. Yasrif Ananda*, J. M.Sharif , M. A. Ngadi,
Dzulkifli Mohammad
Fac. Computer Science and Information System
Universiti Teknologi Malaysia
email : yasrif@siswa.utm.my

M.Mahadi Abdul Jamil
Fac. Electrical Engineering
Universiti Tun Hussein Onn Malaysia
email : mahadi@uthm.edu.my

Abstract

The human red blood cells (RBC) are the most numerous elements of the human blood cells. RBC exist for many kind of functions, such as delivering oxygen to the body tissues via the blood and also transport the carbon dioxide from the cells because of breaking down the nutrients. Lack of this type of human blood cell caused the diseases that are based on the number of these cells such as anemia and polycythemia. In this paper, we present the similarity of two common segmentation methods for a counting cell of RBC using MATLAB, including model simulation for counting the cells. This research main target is getting the similarity of two segmentation or edge detection methods , Sobel and Prewitt, and by this step resulted image , we can counting RBC for getting the number of them which can be used for analyzing the diseases that involved the disorder number of RBC count.

1. Introduction

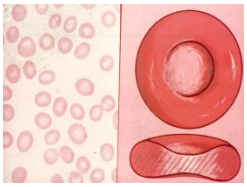
The Human Red Blood Cells (RBC) is the most important type of the human blood cells. Because of this type functions, the human life still exist[1]. In order to analyze the diseases which involved RBC count as a considered parameter, edge detection or segmentation is needed to show the locations of RBC in a slide clearly. The common methods which used to detect the edge of RBC in a slide of human blood cell are Sobel and Prewitt.

The preprocessing algorithms, techniques, and operators are used to perform initial processing that makes the primary data reduction and analysis task easier[2]. This paper presents a similarity of Sobel and Prewitt methods for cell counting model using MATLAB. After detecting the edge of RBC in a human blood cells slide, cell counting is a following step for obtaining the count number of RBC. This cell counting result will be considered as a data which used for analyze the disease based on the number of RBC, whether less, normal, or over.

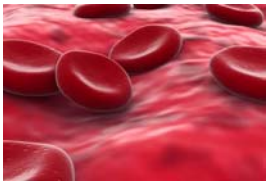
In this paper, characteristics of RBC will be explained shortly in Section 2. Section 3, will present a theory of Sobel and Prewitt methods for edge detection or segmentation. After using the edge detection methods, an algorithm for counting cell will be proposed in Section 4. In Section 5, we do the experimental and result for counting the cells using different method that similar (Sobel and Prewitt). Then, we draw some conclusions and future work perspective in Section 6.

2. Characteristics of Human Red Blood Cells

Red blood cells (RBC) are the most common type of blood cell and the vertebrate body's principal means of delivering oxygen from the lungs or gills to body tissues via the blood[1]. A single drop of blood contains millions of red blood cells which are constantly traveling through human's body[3]. Red blood cells are red only because they contain protein chemical called *hemoglobin* which is bright red in color. The red blood cells of an average adult human male store collectively about 2.5 grams of iron, representing about 65% of the total iron contained in the body. As shown in **Fig 1(a)**, the original two dimensional of red blood cells, which is like a doughnut without a hole and red blood cells looked from electronic microscope. **Fig 1(b)** shows three-dimensional visualization of RBC.



(a)



(b)

Figure 1. Human Red Blood Cells : (a) two dimensional space of RBC [4], (b) three-dimensional visualization of RBC[3].

Otherwise, related to the RBC count numbers analyses, blood diseases that involve the disorder of RBC red blood cell are such as:

- *Anemia* is a disease characterized by low oxygen transport capacity of the blood [5], because of low red cell count or some abnormality of the red blood cells or the hemoglobin.
- *Polycythemias*(or erythrocytoses) are diseases characterized by a surplus of red blood cells[5]. The increased viscosity of the blood can cause a number of symptoms. In *polycythemia vera* the increased number of red blood cells results from an abnormality in the bone marrow. **Fig 2** shows the thicked blood by this disease.

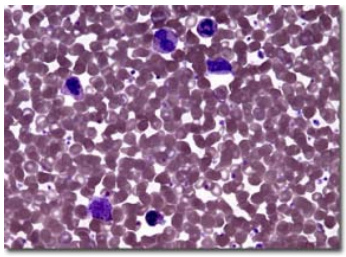


Figure 2. Polycythemia. Image adapted from[6]

Furthermore, several blood tests involve red blood cells, including the RBC count and the hematocrit (percentage) of blood volume which is occupied by red blood cells. And also, the blood type needs to be determined for a blood transfusion or organ transplantation purpose.

3. Sobel and Prewitt Edge detection

Edge detection operators are based on the idea that edge information in an image is found by looking at the relationship a pixel has with its neighbors[2]. If a pixel's gray-level is similar with its around gray-level , there is probably not an edge at that point.

In this paper, we present a comparison of common similar methods of edge detection, Sobel and Prewitt.

Sobel method is a common and simple but effective algorithm for detecting the edge of the image. Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges[7].

Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. In theory at least, the operator consists of a pair of 3×3 convolution kernels as shown in **Fig 3**. One kernel is simply the other rotated by 90°.

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations.

-1	0	+1
-2	0	+2
-1	0	+1

+1	+2	+1
0	0	0
-1	-2	-1

Figure 3. Sobel convolution kernels (Gx and Gy)

The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these *Gx* and *Gy*). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by:

$$|G| = \sqrt{G_x^2 + G_y^2}$$

Typically, an approximate magnitude is computed using:

$$|G| = |G_x| + |G_y|$$

which is much faster to compute.

The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$\theta = \arctan(G_y / G_x)$$

In this case, orientation 0 is taken to mean that the direction of maximum contrast from black to white runs from left to right on the image, and other angles are measured anti-clockwise from this.

Often, this absolute magnitude is the only output the user sees the two components of the gradient are conveniently computed and added in a single pass over the input image using the pseudo-convolution operator shown in **Fig 4.**

Using this kernel the approximate magnitude is given by:

$$|G| = |(P_1 + 2 \times P_2 + P_3) - (P_7 + 2 \times P_8 + P_9)| + |(P_3 + 2 \times P_6 + P_9) - (P_1 + 2 \times P_4 + P_7)|$$

P1	P2	P3
P4	P5	P6
P7	P8	P9

Figure 4. Pseudo-convolution kernels used to quickly compute approximate gradient magnitude

Applied Sobel method to the original image is shown by **Fig 5.**

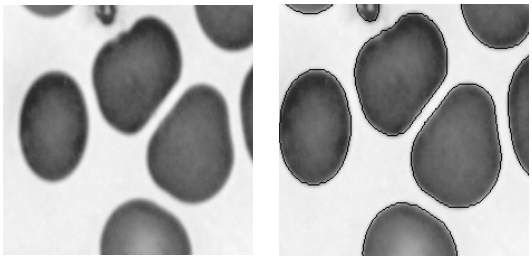


Figure 5. Original and outlined original image using Sobel edge detection method

Sobel method is one of some common methods for detecting the edge of image. Prewitt is one of edge detection methods. Different with Sobel as shown in **Fig 6**, constant values of Prewitt operator are one (1).

-1	0	+1
-1	0	+1
-1	0	+1

+1	+1	+1
0	0	0
-1	-1	-1

Figure 6. Prewitt convolution kernels (Sx and Sy)

This operator also unlike Sobel operator, this operator does not place any emphasis on pixels that are closer to the center of the masks[8]. The implementation of this method to the original image is similar with sobel method closely shown in **Fig 7**.

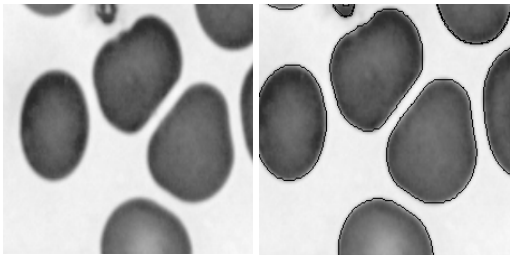


Figure 7. Original image and Prewitt edge detection image

4. Simulation Algorithm for Cell Counting

To count the cell in a slide, a good intensity of an image is needed crucially. And also, a result from edge detection method will affect of counting quality. First, we define an intensity of image. The image that will be defined is an image which is resulted from edge detection. Secondly, we import the image from MATLAB workspace into the input of simulation model. Then, we implement the steps as below:

- Define threshold value
- Convert the image to binary image
- Implement the opening operation to separate overlapping cell (using structure element , the size of structure element is depend on the object shape)
- Labeling each cell
- Count the cell based on the sum of label

The algorithm above is a standard algorithm for modeling the cell counting simulation. The main purpose of this algorithm is to simplify the algorithm for cell counting. Therefore, with this approach, cell counting process will be not time-consuming as like as manual method. By applying algorithm above and using model simulation in MATLAB, the number of entire cells in an original image is 64 for average between Sobel and Prewitt count number result.

5. Experimental and Results

In this section, we present results for cell counting with different methods of edge detection and also different threshold value using MATLAB model simulation. First, we design a model for counting the cells based on the algorithm in section 4 as shown as a

model in **Fig 8**. Secondly, we use the resulted image from edge detection as an input for counting cell.

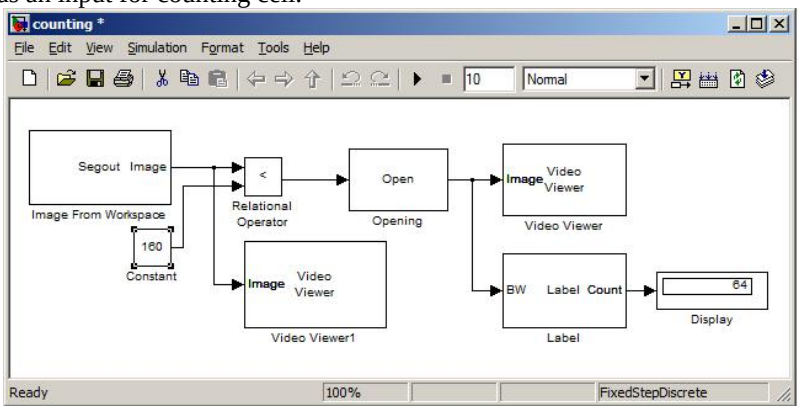


Figure 8. Simulation Model for cell counting using MATLAB

Sobel and Prewitt method that applied to the original image (shown in **Fig 9**) show the similar result in counting cell process. The most significant differences of the result is in the threshold value (constant value based on the model above).

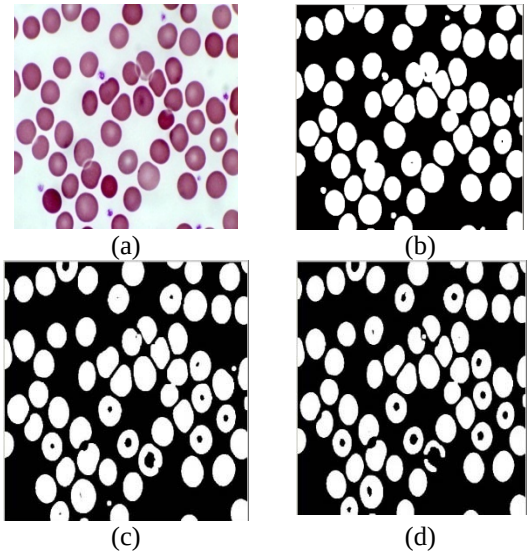


Figure 9. Different result of sobel edge detection based on the threshold : (a) original image, (b) threshold (constant value) = 200 and **n** = 65, (c) threshold = 160 and **n** = 64, (d) threshold = 150 and **n** = 63.

Fig 9.b shows that with an appropriate threshold value (160), the overlapping cell will be separated solely. Otherwise, in **Fig 9.c**, three overlapping cells will be considered as one cell, and in **Fig 9.d,** there is over-segmentation of cell that cause one cell will be separated and counted as two cells. And also, similar with Sobel method, Prewitt edge detection and counting result is similar with the Sobel as shown in **Fig 10.**

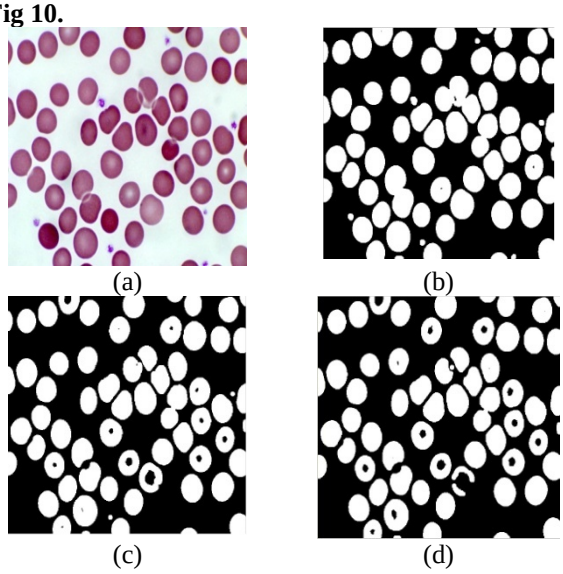


Figure 10. Different result of Prewitt edge detection based on the threshold : (a) original image, (b) threshold (constant value) = 200 and **n** = 65, (c) threshold = 160 and **n** = 64, (d) threshold = 150 and **n** = 63.

6. Conclusions and Future Work

Edge detection is one part of many steps in image processing that is important for supporting next process, segmentation. In this paper, we conclude that Sobel and Prewitt method will have a similar result for cell counting because a similarity kernels that they have. And for the future work, before counting cell analyses, it is better if the classification of objects in

the slide the development of automated threshold is an important factor for performing good results in edge detection and also cell counting.

7. References

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