Analysis of Sobel and Laplacian Edge Detection Algorithms for Blue Plasma Lymphocytes in the Blood Smear of Dengue Fever Patients

Ahmad Fahrudi Setiawan[1(✉)], Yuyun Yueniwati[1(✉)], Kusworini[1(✉)], Setyawan P. Sakti[2(✉)], Aminah Rahmayani Hbs[3(✉)], and Yushidayah Nur Savira[3(✉)]

[1] Doctoral Program of Medical Science, Universitas Brawijaya, Malang, Indonesia
{fahrudimedtech,yuyun,fahrudimedtech,yuyun,kusworinin, aminah}@ub.ac.id, yushidayah@student.ub.ac.id

[2] Physics Department, Universitas Brawijaya, Malang, Indonesia
{fahrudimedtech,yuyun,kusworinin,aminah}@ub.ac.id, yushidayah@student.ub.ac.id

[3] Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia
aminah@ub.ac.id, yushidayah@student.ub.ac.id

Abstract. The presence of Blue Plasma Lymphocytes in a patient's blood sample indicates that the person has been infected with dengue fever. Examination of the blue plasma lymphocytes is carried out under a microscope with visual observation. Blue plasma lymphocytes can now be observed using a computer due to an advancement in digital image processing technology. The computer process to find Blue Plasma Lymphocytes in digital images is edge detection3. Edge detection methods in digital images include the Sobel algorithm and the Laplace algorithm. In order to detect blue plasma lymphocytes, the proper algorithm must be chosen between Sobel and Laplace, so that the results obtained are more accurate.

Keywords: Dengue Fever · Blue Plasma Lymphocytes · Blood Smear · Edge Detection Analysis · Sobel Algorithm · Laplace Algorithm

1 Introduction

Dengue fever is a threat in the tropics during the rainy season every year (WHO 2021). Early detection of dengue fever is necessary for better treatment and prognosis. One strong indication of a patient suffering from dengue is the appearance of blue plasma lymphocytes in his blood. The recognition of blue plasma lymphocytes is done by observing the naked eye under a microscope. Advances in digital image processing technology have enabled computer recognition of blue plasma lymphocytes using edge detection methods (Al-Hafiz et al. 2018). In general, edge detection in digital images is done using the Sobel algorithm or the Laplace algorithm (Kornelis 2019). Both algorithms have their own characteristics, so they are suitable for certain cases and not suitable for other cases. This study aims to determine one of the most suitable edge detection methods for the

Y. Yueniwati et al. (Eds.): ICoMELISA 2021, AHSR 57, pp. 3–8, 2023.
https://doi.org/10.2991/978-94-6463-208-8_2

recognition of blue plasma lymphocytes on blood smears of dengue patients in order to provide the best results.

2 Literature Review

The edge is a set of pixels that are connected and located at the boundary of two areas. Edge detection is used to obtain the edges of the object. Edge detection takes advantage of drastic changes in intensity values at the boundary of two areas. A line or edge is defined as a series of pixels that have an intensity between the initial pixel and the end pixel so that it forms the edge of a digital object. Edge detection algorithms in digital images are based on one of two properties of intensity values, namely detecting discontinuities or detecting similarities (Aliyu et al. 2019). The Discontinuity approach involves solving or sorting digital images based on sudden or considerable changes in intensity. This process discontinues points, lines and edges.

The Sobel algorithm is called the Sobel-Feldman algorithm or Sobel filter. This algorithm is used in digital image processing, especially for edge detection. Discovered by Irwin Sobel and Gary Feldman at the Stanford Artificial Intelligence Laboratory (SAIL). Sobel and Feldman presented the idea of the "Isotropic Image Gradient Algorithm 3x3" in 1968. Technically, the sobel algorithm is a discrete differentiation algorithm for calculating the approximate gradient of the intensity function of a digital image. At each point in the digital image, the result of the Sobel-Feldman algorithm is the corresponding gradient vector or norm of this vector. The Sobel-Feldman algorithm is based on combining images with small filters, which can be separated into integer values in the horizontal and vertical directions, and therefore relatively easy and fast in terms of calculations. On the other hand, the resulting gradient estimates are relatively rough, especially for high-frequency variations in a digital image.

The Sobel algorithm uses the formation of two 3 × 3 kernels wrapped around the original image to calculate the approximate derivative. One for horizontal changes and one for vertical. If we define A as the source image, and Gx, Gy are two images, each containing the approximate vertical and horizontal derivatives, then the calculation is as follows:

$$\mathbf{G}\mathrm{z} = \begin{pmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{pmatrix} * A \text{ and } \mathbf{G_y} = \begin{pmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix} * \mathrm{A}$$

where * indicates the convolution operation of 2-dimensional signal processing. Since the sobel kernel can be decomposed as a product of the average and the differentiation kernel, calculating gradients by smoothing with the Gx example can be written as:

$$\mathbf{G}_\mathrm{z} = \begin{pmatrix} 1 \\ 2 \\ 1 \end{pmatrix} * \left(\begin{bmatrix} +1 & 0 & -1 \end{bmatrix} * \mathbf{A}\right) \text{ and } \mathbf{G}_\mathrm{y} = \begin{pmatrix} +1 \\ 2 \\ -1 \end{pmatrix} * \left(\begin{bmatrix} 1 & 2 & -1 \end{bmatrix} * \mathbf{A}\right)$$

The x-coordinate is defined here as an increase in the "correct" direction, and the y-coordinate is defined as an increase in the "downward" direction. At each point in the image, the resulting gradient estimates can be combined to give the gradient magnitude, using:

$$G = \frac{\sqrt{Gz^2 + Gyz^2}}{1}$$

Using this information, it is also possible to calculate the gradient direction:

$$\Theta = \text{atan}\left(\frac{\mathbf{G}_y}{\mathbf{G}_x}\right)$$

where, $\boldsymbol{\Theta}$ is 0 for the lighter vertical edge on the right side.

Laplace's algorithm is a differential algorithm provided by the gradient divergence of functions in Euclidean space. It is denoted by the symbol ∇·∇, ∇2 (where the ∇ is the nabla algorithm) or Δ. The Laplacian ∇·∇ f(p) of the function *f* at point p is the rate at which the average value of *f* over the spherical centered on p deviates from f(p) as the radius of the spherical shrinks towards 0. In the Cartesian coordinate system, Laplace is given by the sum of the second partial derivatives of the function with respect to each of the independent variables. In other coordinate systems such as cylindrical and spherical coordinates, Laplace also has a useful form.

Laplace's algorithm was invented by the French mathematician, Pierre-Simon de Laplace (1749–1827). The first application of this algorithm to study celestial mechanics was to provide a constant multiple of masses when applied to potential gravity due to the distribution of mass at a given density. The solution of the equation Δ f = 0, called the Laplace equation, is a harmonic function and represents the possibility of a gravitational field in the vacuum area. Laplace occurs in differential equations that describe many physical phenomena, such as electric potential and gravity, diffusion equations for heat and fluid flows, wave propagation and quantum mechanics. Laplace represents the flux density of the gradient flow of a function. Laplace's algorithm is widely used in science to model all kinds of physical phenomena. Laplace is the simplest elliptic algorithm and is the core of Hodge's theory and de Rham's cohomology results. In digital image processing, the Laplace algorithm is used for various tasks such as blob detection and edge detection (Zakariya 2019).

Laplace's algorithm is a second-order differential algorithm in n-dimensional Euclidean space, which is defined as the divergence (∇•) of the gradient (∇f). So, if f is a real feasible function that can be differentiated twice, then the Laplace of *f* is defined by:

$$\Delta f = \nabla^2 f = \nabla \cdot \nabla f$$

where the last notation comes from formal writing:

$$\nabla = \left(\frac{\partial}{\partial x_1}, \ldots, \frac{\partial}{\partial x_n}\right)$$

Equivalently, the Laplace of *f* is the sum of all the second partial derivatives not mixed in cartesius xi coordinates:

$$\Delta f = \sum_{i=1}^{n} \frac{\partial^2 f}{\partial x_i^2}$$

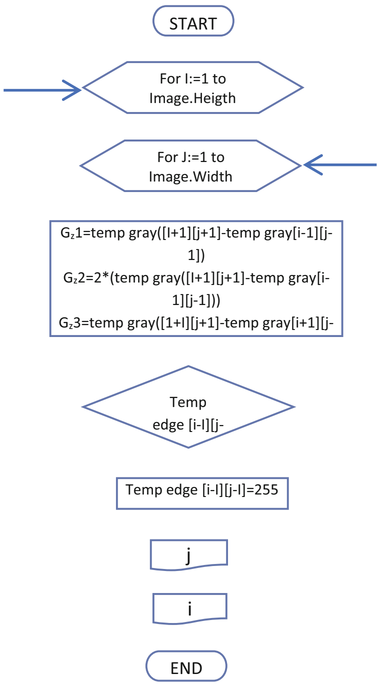
As a second-order differential algorithm, Laplace's algorithm maps the Ck function to the Ck^{-2} function for k $\geq$ 2. Expression (1) or its equivalent (2) defines the algorithm Δ:C k(Rn) $\rightarrow$ Ck $-$ 2(R n) or more commonly the Δ: Ck (Ω) algorithm $\rightarrow$ Ck 2 (Ω) for each set open Ω.

3 Methods

The research process is divided into five steps:

1. Prepare a digital image of the blood smear of dengue patients who have blue plasma lymphocytes.
2. Test those digital images using edge detection with Sobel algorithms and Laplace algorithms.
3. Visually observe the test results of step 2.
4. Test the image using the acceptability limit of the edge-composing pixels.
5. Observe the test results from step 4.

For testing using the Sobel algorithm, follow these steps:



4 Result

Figure 1 is the result of edge detection using the sobel algorithm.

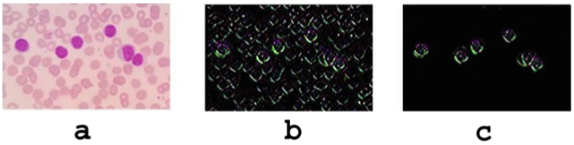


Fig. 1. Edge Detection Results using the Sobel Algorithm

The picture above shows the edge detection of blue plasma lymphocytes using the Sobel algorithm on the image of positive blood smear for dengue fever, where is, a) is the original image, b) is the edge detection image with Sobel, c) the image of the blue plasma lymphocyte that detects the edge of the Sobel algorithm.

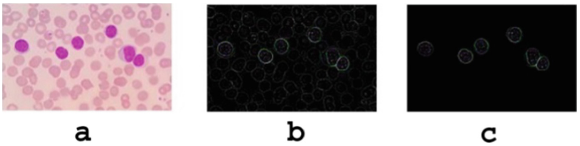


Fig. 2. The result of edge detection using the Laplace algorithm

The picture above shows the edge detection of blue plasma lymphocytes using the Laplace algorithm on the image of positive blood smear for dengue fever, where is a) is the original image, b) is the edge detection image using the Laplace algorithm, c) the blue plasma lymphocyte image is subject to edge detection by the Laplace algorithm.

5 Discussion

Visual observation in Fig. 1 with Sobel algorithm obtained dominance of the shape of the edges of human blood cells that are straight both vertical horizontally and diagonally with generally bad results. While the visual observation in Fig. 2 with laplace operation is a good form of human peripheral blood cells.

No	Parameters	Sobel	Laplace
1	Edge clarity	Unclear	Clear
2	Edge Connection	Not continued	Continued

The Edge Compiler's Acceptance Limit can be measured using grayscale by making the test result image contain only two intensity values, namely 10 and 245 on a gray scale of 0 to 255. The value 245 (bright intensity) does not characterize the object's edge; it is taken from the total intensity value of the test image, which ranges between 0 and 50. Meanwhile, the value 10 (dark intensity) characterizes the object's edge, which is obtained from all of the intensity values of the test image results, which range from 51 to 255. The dark intensity in this study resulted from the acceptance of 80% of the pixels that made up the edges.

6 Conclusions

Based on the results of the tests that have been carried out, it can be concluded:

1. Based on visual observations, it was concluded that the Laplace algorithm has a better performance than the Sobel algorithm.
2. Based on the observation of the highest number of pixels composing the edges of objects, it can be concluded that the Laplace method has a better performance than the Sobel algorithm.
3. The results of this study concluded that the Laplace algorithm can be used as a blue plasma lymphocytes detection from peripheral blood in dengue fever patients.

7 Suggestion

Suggestions for the development of similar research are:

1. To get better results for further digital image processing, it is necessary to process gray level and improve image quality such as sharpening.
2. The use of Laplace algorithm is suitable for edge detection of blue plasma lymphocyte cells, but not necessarily suitable for other applications, so for other purposes in digital image processing, other research is needed.

References

Al-Hafiz, F., Al-Megren, S. and Kurdi, H. (2018) ‘Red blood cell segmentation by thresholding and canny detector’, Procedia Computer Science, 141(November), pp. 327–334. doi: https://doi.org/10.1016/j.procs.2018.10.193.

Aliyu, H. A. et al. (2019) ‘Segmentasi dan deteksi gambar darah merah sel sabit Segmentasi dan Deteksi Gambar Darah Merah Sel Sabit’, 020004(November).

Dronacharya, U. (2020) ‘Detection of white blood cells using sobel edge detection’, (May 2019).

Kamiswara, A. and Sukoco, A. (2017) ‘Quality Comparison Between Edge Detection Method Based On Scale Sobel Canny and Good Image’, (Icetd), pp. 724–733.