Comparative Analysis of Image on Several Edge Detection Techniques

Adi Budi Prasetyo [1], Rizki Wahyudi [1], Imam Tahyudin [1], Selvia Ferdiana Kusuma [2,3], Luzi Dwi Oktaviana [1], Azhari Shouni Barkah [1], Budi Artono [1]

[1] *Universitas Amikom Purwokerto, Purwokerto, Indonesia*
[2] *Politeknik Elektronika Negeri Surabaya, Surabaya, Indonesia*
[3] *Politeknik Negeri Madiun, Madiun, Indonesia*

Abstract **– Edge detection of an image is needed to obtain information related to the size and shape of an image. There are numerous methods for detecting edges, including the Prewitt, Laplace, and Kirsch operators. Each edge detection method has different performance and results. Therefore, this study aims to analyze the performance comparison of the Prewitt, Laplace, and Kirsch operators. The analysis process is carried out using MSE, PSNR and Image Contrast values. Based on the experiments that have been carried out, the best edge detection is produced by the Prewitt operator. The average MSE and PSNR values obtained were 4.63 and 41.79 dB. The Laplace operator is good in the contrast value of 17.77. However, the contrast value only serves as a supporting parameter to clarify the differences in the results of each edge detection operator. So it can be concluded that the Prewitt edge detection method is the best method among the other two methods.**

Keywords **– Edge Detection, Kirsch, Laplace, MSE, PSNR, Prewitt.**

1. Introduction

Image processing is needed to enhanced the quality of the image to be processed, so that later the image can be easily interpreted by humans or machines [1], [2], [3].

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Corresponding author: Rizki Wahyudi,
Universitas Amikom Purwokerto, Purwokerto, Indonesia.
Email: rizkiw@amikompurwokerto.ac.id, rizki.key@gmail.com

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Several types of image processing operations, such as Image enhancement, image restoration, image segmentation, image analysis, and image reconstruction are all subcategories. The image analysis process is needed to identify parameters related to the characteristics of objects in the image, then use these parameters to interpret the image [4], [5]. Image analysis consists of 3 stages, namely, feature extraction, segmentation, and classification. The key factor in feature extraction is the ability in edge detection.

Edge detection in the image is the process of generating the edges of objects in the image so that the boundary line information in the image can be displayed [6]. The purpose of edge detection is to improve image detail that contains noise [7]. Edges of image are considered as important features in images for estimating the attributes and structure of edge objects that are usually recognized at the border between two different image regions [8]. The edge detection method is divided into seven operators, namely the Sobel operator, Roberts operator, Laplace operator, Canny operator, Prewitt operator, Laplacian of Gaussian (LoG) operator, and Kirsch operator [9]. Improper use of edge detection operators will result in failed detection [10].

Assessment of edge detection quality can be done objectively using the calculation of Mean Squared Error (MSE), Peak Noise to Signal Ratio (PSNR) and Histogram value. MSE is the average squared error between the actual value and the forecast value. PSNR is the ratio of the maximum value of the bit depth measured by the amount of influential noise [11]. The histogram is a graph that describes the spread of pixel intensity values of an image. Histograms can be used to find out important information from an image. In addition to objectively assessing the quality of edge detection, there is also a subjective quality assessment using the human senses. However, this is difficult to do because the assessment is very dependent on human vision [12].

Research related to the method of edge detection or comparison of edge detection methods has also been carried out in the past.

Kuswandi and Fadillah conducted a study on the effectiveness of the Robbert method and the Prewitt method in detecting edges in signatures [13]. The edge detection process in the Robbert and Prewitt methods is obtained by adding up the absolute value of the differential convolution in the horizontal direction with the differential convolution in the vertical direction. The result shows that the Prewitt method has a higher level of accuracy than the Robbert method.

Rani et al, [14] compared the efficiency of the Sobel, Laplacian, and Hough Transform edge detection algorithms for detecting edges in metallic and non-metallic images. Different parameters are used for comparisons, including edge detection accuracy, noise removal efficiency, and execution speed. Regarding voids, boundaries, lines or curves, and orientation detection, Laplacian performs better than other detection algorithms.

Ghosal [15] conducted a research on steganography that utilizes the Kirsch method to perform edge detection as a support for the steganograph process. The research shows that the Kirsch edge detector is capable of producing more edge pixels than existing traditional edge detectors.

Based on the literature study that has been carried out, it is known that edge detection using the Prewitt, Laplace, and Kirsch operators has proven to be superior for image edge detection in each study. However, each study uses different comparisons and parameters so that the results obtained are not really considered to represent the quality.

Therefore, this study compares the three operators using MATLAB programming with measurement parameters MSE, PSNR and the Constrast value. The purpose of this comparison is to compare the quality of each edge detection operator from previous studies using the same parameters and assessment methods.

2. Method

This research consists of two main stages, namely the image edge detection and the assessment of the results of the image edge detection from each operator. Details of the research flow are shown in Figure 1.

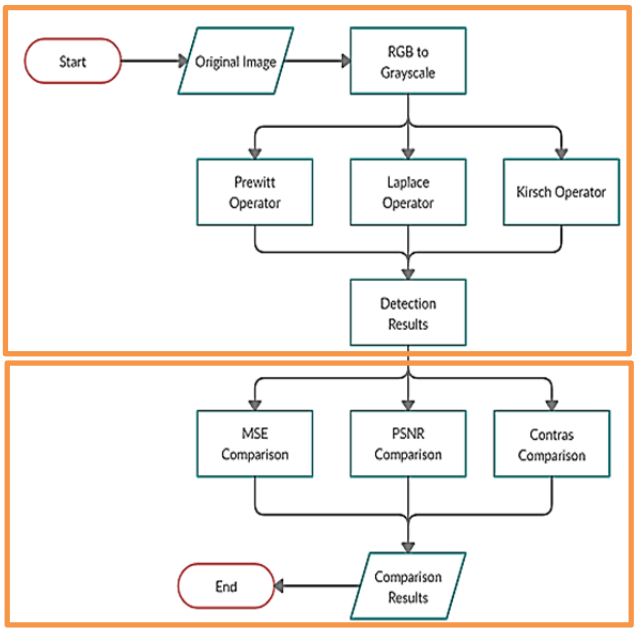


Figure 1. Flow of edge detection comparison

In the edge detection phase, several stages are carried out. The first stage is to input six original images. The images used as datasets are chosen randomly but still represent various levels of edge detection difficulty. The original image still uses the RGB color model. Then the second stage changes the RGB Image to Grayscale. This is necessary because the edge detection method can only detect edges in images with grayscale mode [16]. The third step is to perform an edge detection operation. After the images are converted into grayscale color mode, then the six images that have been changed will be detected using three edge detection operators, namely Prewitt, Laplacre and Kirsch. The edge detection results from the three operators were then compared and assessed with the same parameters, namely MSE, PSNR and Contrast value.

The edge detection assessment is carried out in several stages, starting from the edge detection assessment using MSE, PSNR then using the Contrast value. The results of the assessment are then presented in the form of tables and graphs to facilitate the process of analyzing the results.

3. Results and discussion

The findings are discussed in this chapter of edge detection in six images that have been collected using three edge detection methods, namely Prewitt, Laplace, and Kirsch. Then compare the MSE, PSNR and Contrast values of each edge-detected image.

3.1 Edge detection

Edge detection is a process to find changes in intensity that are significantly different in an image field. Detection edge functions to obtain the edge of the object, edge detection takes advantage of drastic changes in intensity values at the boundary two areas [17],[18]. An edge is a set of pixels that are connected and lie on the boundary of two areas, an edge that contains information very important, the information obtained can be in the form of shape or size of the object. As for some examples of detectors, the first edge is the Gradient based operator (first derivative), namely the Robert, Sobel, and Prewitt operators. The second are operators based on the second derivative, namely the Laplacian operator and the Laplacian Gaussian operator.

3.1.1 Input image

The images that have been collected as research material are then entered into the MATLAB software. The images used are labeled in table 2 with RGB color mode. Figure 2 represents an image used as a dataset in this study. The selection of images used as a dataset is based on the level of edge detection difficulty of each image. Furthermore, the images are changed from RGB color mode to grayscale color mode.

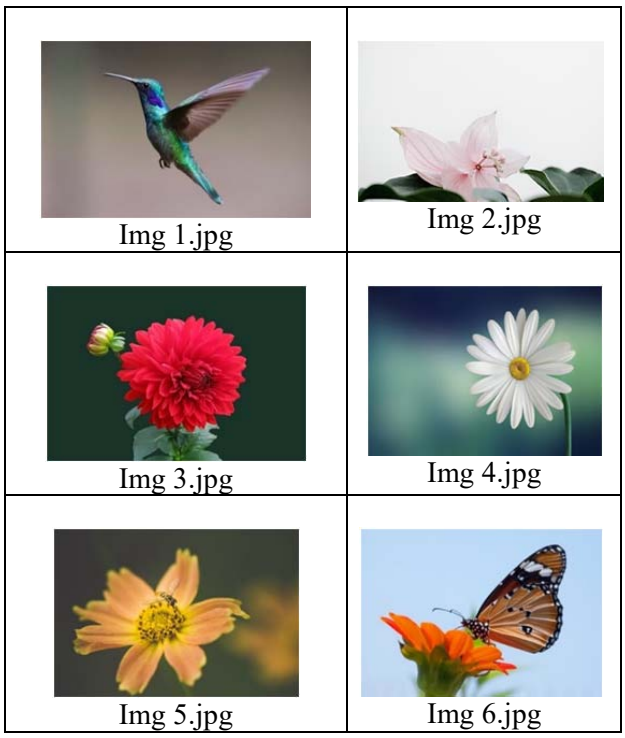


Figure 2. Dataset for edge detection

3.1.2 Converting image and edge detection process

At this stage the image that has been entered into the MATLAB software is converted into Grayscale mode. This is necessary because the edge detection process can only be done using images with Grayscale color mode. After the image is converted to grayscale then it goes to the next stage, namely the edge detection process with the Prewitt, Laplace and Kirsch operators.

3.1.3 Prewitt operator

After converting the image to grayscale, the next step is to perform edge detection using the first edge detection method, the Prewitt operator. The code to perform edge detection using the Prewitt operator applies the convolution formula for the Prewitt operator, then proceeds to display the edge detection image, and the final stage produces a complete image. Edge detection file with the name “Prewitt.jpg".

3.1.4 Laplace operator

The Laplace operator is the second edge detection operator. After converting the original image to grayscale, edge detection is performed using the second operator, namely Laplace. The code to perform edge detection using the Laplace operator applies the convolution formula for the Roberts operator, then proceeds to display the edge detection image, and the final stage produces a complete image. edge detection file with the name “Laplace. jpg".

3.1.5 Kirsch operator

The Kirsch operator is the third edge detection operator. After the original image is adjusted to grayscale, the third operator, Kirsch, is used to detect edges. The code to perform edge detection using the Kirsch operator applies the convolution formula for the Kirsch operator, then proceeds to display the edge detection image, and the final stage produces a complete image. edge detection file with the name “kirsch.jpg".

3.1.6 Results from edge detection

After successfully detecting the edges of the image, a complete file will be formed in the previously adjusted directory. The intact file is used in measuring the MSE, PSNR and Contrast values.

The results of edge detection using three edge detection operators, namely Prewitt, Laplace, and Kirsch, produce 18 binary image outputs, as shown in Figure 3. The overall image resulting from edge detection is then assessed using an assessment based on MSE, PSNR and Contrast values.

3.2 Comparison of MSE, PSNR and contrast values

After performing edge detection on the six original images, the next step is to calculate the MSE, PSNR and Contrast values, these three parameters are used to compare the results of image processing with the initial image and the original image

3.2.1 Calculation of MSE

Calculation of MSE using 18 binary images resulting from the edge detection that was carried out in the first stage. The code for calculating the MSE value for 18 binary images is shown below:

```
1. Imagel=imread('prewit.jpg');
2. if size(Imagel, 3)==3
3. Imagel=rgb2gray(Imagel);
4. end
5. Image2=imnoise(Imagel,'salt & pepper',0.2);
6. [baris,kolom]=size(Imagel);
7. MSE = sum(sum((Imagel-Image2).^2))
8. /(baris*kolom)
9. Psnr = 10*log10(256*256/MSE)
```

The results of calculating the MSE value of each edge-detected image using three detection operators, namely Prewitt, Laplace, and Kirsch, are shown in Table 1.

Table 1. MSE value of each image in each method

Method	1	2	3	4	5	6
Laplace	9.69	13.21	3.46	12.08	10.02	12.38
Kirsch	11.45	19.99	7.72	13.92	12.42	16.3
Prewitt	3.35	7.82	3.89	3.44	3.02	6.22

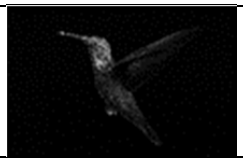
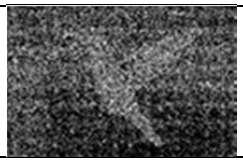
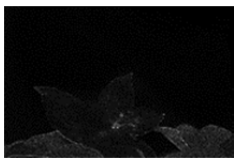
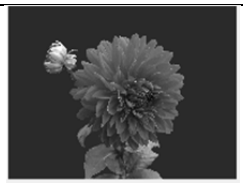
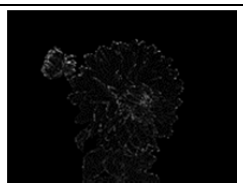
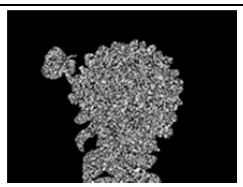
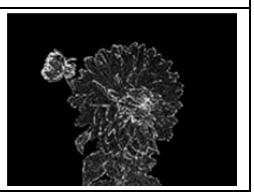
Based on Table 1 the overall average value of edge detection operators on the Laplace operator is 10.15, the Kirsch operator is 13.64 and the Prewitt operator is 4.63.

3.2.2 Calculation of PSNR

After performing edge detection on the six images of the research material, the next step is to calculate the PSNR value of the 18 binary images from the edge detection that was carried out in the first stage. The code to calculate the PSNR value for 18 binary images is as follows:

```
1.  Imagel=imread('prewit.jpg');
2.  if size(Imagel, 3)==3
3.  Imagel=rgb2gray(Imagel);
4.  End
5.
6.  Image2=imnoise(Imagel, 'salt &
    pepper',0.2);
7.  [baris,kolom]=size(Imagel);
8.
9.  MSE = sum(sum((Imagel-
    Image2).^2))/(baris*kolom)
10. Psnr = 10*log10(256*256/MSE)
```

Table 2 shows the results of calculating the PSNR value from each edge-detected image using 3 detection operators, namely Prewitt, Laplace, and Kirsch.

	Original	Detection Results Prewitt	Detection Results Laplace	Detection Results Kirsch
Image 1.jpg				
Image 2.jpg				
Image 3.jpg				

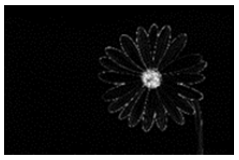
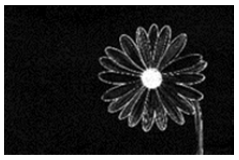
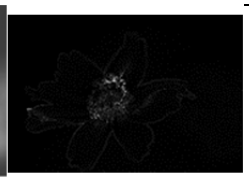
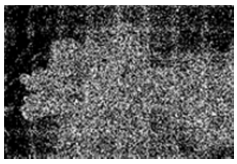
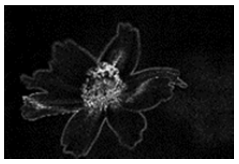
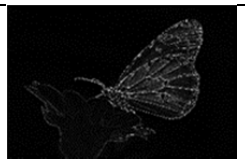
	Original	Detection Results Prewitt	Detection Results Laplace	Detection Results Kirsch
Image 4.jpg				
Image 5.jpg				
Image 6.jpg				

Figure 3. Results of edge detection images

Table 2. PSNR value of each image in each method

Method	1	2	3	4	5	6
Laplace	38.29	36.95	41.52	37.34	38.15	37.23
Kirsch	37.57	35.15	39.28	36.72	37.22	36.03
Prewitt	42.90	39.23	42.26	42.79	43.36	40.22

Based on Table 2, the average PSNR value of all edge detection operators on the Laplace operator is 38.25, the Kirsch operator is 36.99 and the Prewitt operator is 41.79. So it can be concluded that the

Prewitt edge detection method has the highest average PSNR value compared to the others and makes it the best detection compared to the Laplace and Kirsch operators. It is possible to conclude that image quality is good if the PSNR value is greater than 30 dB, and the higher the mass value, the better.

3.2.3 Calculation Of contrast

The contrast value of the image is assessed using texture analysis in MATLAB. Figure 4 is a display of the implementation of the contrast value in the code in MATLAB 3.33.

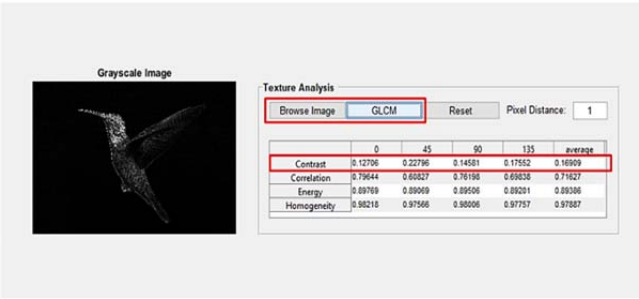


Figure 4. Implementation of Contrast Value in Matlab

Table 3 presents the findings of calculating the Contrast value of each image whose edges have been detected using 3 detection operators, namely Prewitt, Laplace, and Kirsch.

Table 3. Contrast value of each image in each method

Method	1	2	3	4	5	6
Laplace	16.31	23.31	7.43	21.40	17.36	20.84
Kirsch	0.39	1.10	0.47	0.38	0.26	0.77
Prewitt	0.16	0.16	0.09	0.25	0.02	0.24

Based on Table 3, it is known that the average Contrast value for the Laplace operator is 17.7, the Kirsch operator is 0.5 and the Prewitt operator is 0.15. The Contrast value on the Laplace operator has the highest average value which is very significant, but the average value for the other operators is very low. However, the Contrast value only serves as a supporting parameter to clarify the differences in the results of each edge detection operator.

3.2.4 Comparison result on MSE, PSNR and contrast value calculation

The results of the comparison of edge detection assessments using the MSE, PSNR and Contrast Value parameters from the six images can also be seen in the graphs of Figures 5 to 7. Figure 5 depicts a graph of the findings of comparing MSE values on the entire image. The Prewitt operator always shows the lowest graph while the Kirsch operator always shows the highest graph. So it can be concluded that the Prewitt edge detection method has the lowest average MSE value compared to the others.

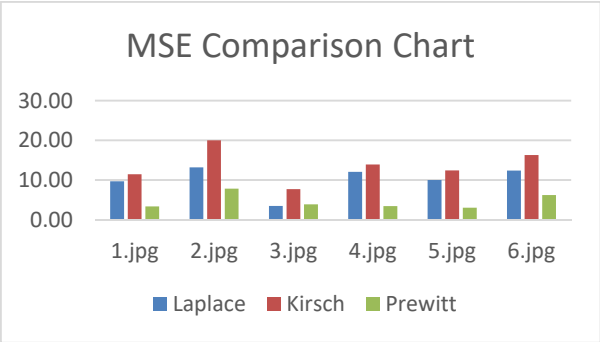


Figure 5. MSE Comparison Chart

Figure 6 depicts the findings of the comparison test for the PSNR value on the entire image. The Prewitt operator always shows the highest graph while the Kirsch operator always shows the lowest graph. So it can be concluded that the Prewitt edge detection method has the highest average PSNR value compared to the others.

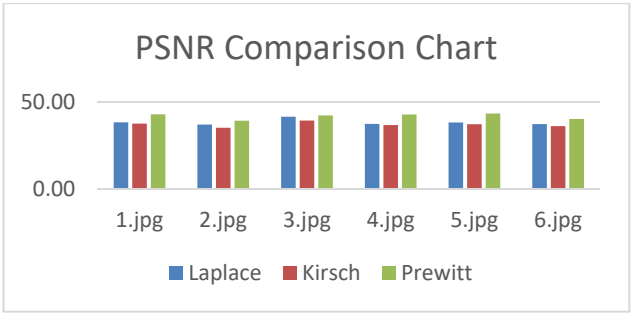


Figure 6. PSNR Comparison Chart

Figure 7 shows a graph of the difference in the contrast value of the edge detection image. This graph shows that the Laplace operator has the highest value with a significant difference compared to other operators.

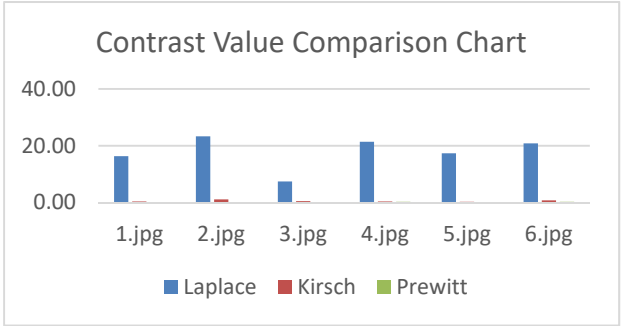


Figure 7. Contrast Value Comparison Chart

The comparison of Contrast values is done to find out the differences that exist in each edge detection so that the Contrast value is not the main parameter in this study. Contrast serves as a supporting parameter to clarify the differences in the results of each edge detection operator.

When compared with the results of previous studies, this study produces new information that the Prewitt operator is superior to the Laplace and Kirsch operators in terms of image edge detection.

4. Conclusion

Prewitt, Laplace, and Kirsch operators are several methods that can be used to perform edge detection in an image. According to the findings of the edge detection quality analysis using MSE, PSNR, and Contrast values on the Prewitt, Laplace, and Kirsch operators, it is known that the best edge detection is produced by the Prewitt operator with an average PSNR value of 41.79 dB while the average value of the Laplace and Kirsch operators is 41.79 dB. PSNR of 38.25 dB and 36.99 dB. The lowest MSE value is owned by Prewitt operator with a value of 4.62. Laplace and Kirsch operators have an average MSE value of 10.14 and 13.64. The comparison of Contrast values shows that the Laplace operator has the highest score with an average of 17.77. However, the Contrast value only serves as a supporting parameter to clarify the differences in the results of each edge detection operator. So it can be concluded that the Prewitt edge detection method is the best method among the other two methods because it has the highest PSNR value and the lowest MSE value.

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