Edge detection in noisy images with different edge types

M F V Ruslau¹, R A Pratama¹, Nurhayati¹ and S Asmal²
¹Department of Mathematics Education, Faculty of Teacher Training and Education, Universitas Musamus, Merauke, Indonesia
²Department of Industrial Engineering, Faculty of Engineering, Universitas Hasanuddin, Makassar, Indonesia

Email: maria_fkip@unmus.ac.id

Abstract. Edge Detection in an image is a process that produces edges of image objects, the purpose of which is to mark the parts that become detailed images to improve the details of blurry images, which occur due to the effects of the image acquisition process. Edge is defined as a change in the intensity of a large distance. Based on changes in intensity, there are three types of edges in digital images, namely, step edges, ramps edge, and noisy edge. On step edges where the intensity or gray value changes very fast The Gradient Method is able to detect better. On the ramp edge where the gray value slowly changes the Laplace method is able to detect better than the Gradient Method. On a noisy edge, the existence of noise in the image can bring up the other edges around the actual edge and can also shift the actual edge position.

In this study, the authors conducted edge detection in the image by means of determining the right edge detection method to detect edges in noisy images. Noise is obtained by generating a Gaussian Noise in the image. The results showed that, without filtering the image, in noisy edge, the LoG operator was able to detect edges and reduce noise better than Canny. However, by selecting the right threshold that matches the \( \sigma \) (standard deviation), Canny also capable to provide good edge detection results.

1. Introduction

One of the main stages in image processing is the edge detection process, with this process the boundary between objects and backgrounds can be determined properly. The number of edge detection methods that exist today can raise doubts in making decisions about the use of the right method and in accordance with the condition of the image detected. Determining the edge of an image is easy if the image conditions are clear and sharp (sharp), but the accuracy of the existence of the edges becomes difficult to determine if the image is disturbed, such as noise [1-3]. In fact, the acquisition image is not always clean from noise. For reasons to simplify and help determine the existence of edges, there have been a lot of developed methods of image edge detection, including Sobel operators, Canny operators, Prewitt operators, Laplace, etc [4-7].

Based on changes in intensity, there are three types of edges that exist in digital images, i.e step edge, ramp edge, and edge contains noise. The step edge has a very sharp intensity change with the edge 90°. A ramp or wide edge, i.e. an edge with a small edge angle, sloping can also be interpreted as a number of adjacent edges. Whereas edge noise in digital image format does not have a certain pattern. The intensity of noise is random, so its presence can bring up other edges around the actual edge, besides that it can also shift the actual edge position.

There are several ways to do edge detection but commonly used are the Gradient Method and Laplacian Method [8]. The Gradient method is perfect for detecting ramp edges where pixels of gray
level change very slowly. The Canny operator is known as one of the best first gradient edge detection operators compared to other first gradient detection operators. Using the Canny Operator, the edges appear clearer, the difference between the edges and the image background is obvious. But the noise in certain parts cannot just disappear. For images where the gray level changes quickly from dark to bright, the gradient operation will produce a widening edge. The disadvantage of applying the Laplacian Method is very sensitive to noise. Therefore, it is often combined with a Gaussian function called Laplacian of Gaussian (LoG) and the results of edge detection with this method can be increased by applying thresholding [9].

The selection of an edge detection operator is not appropriate, consequently, it can lead to the resulting inaccuracy of the edges and can affect the subsequent analysis process [10]. Based on these conditions, knowledge or information about the needs of each operator is needed [10]. Which removes noise by using a different type of filter, based on the problems mentioned above, the authors are interested in detecting edges using Canny and LoG edge detector on various types of digital images, without applying the noise removal method [11]. The purpose is to analyze the extent to which the two methods can provide satisfactory edge detection results according to the condition of images/objects or images with different edge types. In this study, we estimate the characteristics of an image just by looking at the details on the histogram. The x-axis shows the grey levels (e.g. from 0 to 255), the y-axis shows their frequency in the image [12].

2. Method
Image samples used are images that have different levels of intensity change (images with step edges, ramps edges, and noisy images). The images used in this study were taken intentionally and included in MATLAB. Then the test images are converted into intensity images or gray images and gray values are displayed in the histogram to determine the edge type of the images. Image noise is obtained by generating Gaussian noise in the image. Adds zero-mean, Gaussian white noise with a variance of 0.01 to a grayscale image.

2.1. Edge detection algorithm

1) Downloading image. At this stage what is done is to read the image with the imread('image') command or from the file menu, import data.
2) Convert images into a grayscale image with rgb2gray (image) command
3) Displays the histogram of image intensity with imhist(image) command.
4) Identify the type of image edge.
5) Generating Gaussian noise in images with commands imnoise (image, 'gaussian').
6) Intensification: Apply differentiation to enhance the quality of edges.
   - Detect edges using edge (Image,'canny') commands or edge(Image,'canny',thresh,sigma).
   - Detect edges using edge (Image,'log') commands or edge(Image,'log',thresh,sigma).
7) Threshold: Edge magnitude threshold is used to reject the noisy edge pixels and others should be confined.
8) Displaying the Image. Display the output image with the imshow(image) command. The image results from edge detection, then it will be interpreted for the sake of further analysis

2.2. Interpretation image output.
An edge detection method can be said to detect the most optimal edge if it meets the criteria, as follows:

1) Clear response. There is only one response for each edge, so it is easily detected and does not cause confusion in subsequent image processing.
2) Another test for edge detection is to use resistance to noise. Interference in the input image can be used as a parameter that determines the level of appearance of several methods to track the edges of an object.
3. Other parameters are by looking at the strength, smoothness, and thickness of the edges of the resulting image output, which can clearly distinguish objects from the background.

3. Result and discussion
Image as an object in this study is an RGB image. The experiment is carried out by generating an image and then converted to an image intensity (grayscale) with 256 gray level. Image intensity is a grayscale image that has the possibility of a color between black (minimum) and white (maximum) with intensity between 0 to 255. These images include the tree image.jpg measuring 1280x686, twilight image.jpg measuring 909x584, and rice image.jpg measuring 864x576. The images mentioned above will be detected by the edges using Canny Operators and LoG Operators. The experimental results are presented as follows:

![Figure 1](image1.png)
**Figure 1.** Original image, image intensity and gray level histogram of tree image.jpg(1280x686)

![Figure 2](image2.png)
**Figure 2.** Original image, image intensity and gray level histogram of twilight image.jpg(909x584)

![Figure 3](image3.png)
**Figure 3.** Original image, image intensity and gray level histogram of rice image.jpg(864x576)

In Figures 1(c) and 2(c), it can be seen that there are three histogram peaks where the difference in the number of pixels between levels of the histogram is very large. There is a very deep and wide
valley between the three peaks which causes the histogram peak distance far enough and states that there is a very sharp change in the gray value composition. So, it can be said that the tree image and twilight image have a step edge. Figure 3(c) shows that there are two peaks and two hills separated by a valley that is quite steep, but narrow and the two hills are quite wide. This shows that the distance or the difference in the number of pixels between the levels of the histogram is small so that it can be said that the change in the composition of gray values in rice images.jpg is not sharp. So, it can be said that the rice image has a ramp edge. The fact is that the rice image contains two types of edges, namely, step edges in a small portion of the image (a pile of rice on the left side of the image and background) and a ramp edges on the right side of the image. Because the sloping part is more dominant than the steep part, the rice image is classified as an image with a ramp edge.

3.1. Generating noisy image
Focus in this paper is a noisy image. To obtain the image, an experiment was performed by generating Gaussian noise in the image. The experimental results are presented as follows:

![Figure 4. Noisy image and gray level histogram of tree image](image)

![Figure 5. Noisy image and gray level histogram of twilight image](image)

![Figure 6. Noisy image and gray level histogram of rice image](image)

Based on the Figure above, it can be seen that giving noise greatly disrupts gray values in the image. This can be seen from the difference in changes in gray color composition that is on the histogram. Where the difference in gray values between levels of the histogram is totally different from the original image. This will be very influential in the image edge detection process. Then it will be seen the ability of each operator to detect noisy images with certain edge characteristics.
3.2. **Edge detection with canny edge detector**

The results of edge detection in noisy image using the Canny operator with $\sigma = 1$ presented as follows:

![Figure 7](image)

**Figure 7.** Edge detection results using canny operator with $\sigma = 1$

Based on Figure 7, it can be seen that the noise intensity detected is still very much. Canny operators with $\sigma = 1$, are not able to reduce noise and detect well, especially in images with step edges (Figures 7a & 7b). In images with a ramp edge (Figure 7c), Canny Operators can reduce noise and detect image edges well even though the possibility of false edges appearing is very large.

![Figure 8](image)

**Figure 8.** Edge detection results using canny operators with various threshold and $\sigma$ values.

Figure 8 shows the results of edge detection obtained by applying several thresholds. The results show the interval of the threshold value that must be chosen so that the results are good for $\sigma = 1$ and $\sigma = 2$. The results show that the greater the $\sigma$ value used, the selected threshold must be small. It can also be seen that for each $\sigma$ value with a low threshold the noise is still detected well, but by increasing the threshold the results obtained can be better. The side effects that are caused are causing the edges to be reduced along with noise and for the large $\sigma$ values, the resulting edges are thicker.

3.3. **Edge detection with LoG**

The results of edge detection in noisy image using the LoG operator with $\sigma = 2$ presented as follows:
Figure 9. Edge detection results using LoG operator with $\sigma = 2$

From Figure 9 above, it can be seen that LoG with $\sigma = 2$ is able to reduce noise very well, both in images with step edges and ramp edges. However, the quality of the resulting edge is still not good.

Figure 10. Edge detection results using LoG operators with various threshold and $\sigma$ values.

Figure 10 shows the interval of the threshold value that must be chosen so that the results obtained are good for each $\sigma$ using the LoG Operator. The results show that the greater the $\sigma$ value used, the selected threshold must be small. It can also be seen that for each $\sigma$ value with a low threshold the noise is still detected well, but by increasing the threshold the results obtained can be better. However, we cannot take a threshold that is too large than the existing range because it will cause the edge to be reduced along with noise.

The edge detection result of the rice image, that is the image with a ramp edge with $\sigma = 1$ (Figure 10i & 10j) shows that by using a large threshold value can reduced noise well. But, many edges are missing and the resulting margins are very bad in this case the continuation of the edges especially at sloping part. Whereas for $\sigma = 2$, the resulting image is better. Where LoG is able to reduce noise well and the missing edge information is less even though the resulting edge is not good.
4. Conclusion

Based on the results and discussion, it can be concluded that at the noisy image, the LoG operator is able to reduce noise better than the Canny Operator. On noisy image with step edges, edge detection result by Canny operator can be increased by adjusting or selecting the right threshold values according to the \( \sigma \) (standard deviation) used. To obtain good edge detection results, it should be noted about the selection of threshold and the appropriate standard deviation for each edge type.

References

[1] Boyat A K and Joshi B K 2015 A review paper: noise models in digital image processing arXiv Prepr. arXiv1505.03489
[2] Ranjbaran A, Hassan A H A, Jafarpour M and Ranjbaran B 2015 A Laplacian based image filtering using switching noise detector Springerplus 4 119
[3] Kandwal R, Kumar A and Bhargava S 2014 Existing image segmentation techniques Int. J. Adv. Res. Comput. Sci. Softw. Eng. 4
[4] Nahar M and Ali S 2014 An Improved Approach for Digital Image Edge Detection Int. J. Recent Dev. Eng. Technol. 2
[5] Chandwadkar R, Dhole S, Gadewar V, Raut D and Tiwaskar P S A 2016 Comparison of Edge Detection Techniques
[6] Chandwadkar R, Dhole S, Gadewar V, Raut D and Tiwaskar S A 2013 Comparison of edge detection techniques Proceedings of Sixth IRAJ International Conference, Pune, India
[7] Vijayarani S and Vinupriya M 2013 Performance analysis of canny and sobel edge detection algorithms in image mining Int. J. Innov. Res. Comput. Commun. Eng. 1 1760–7
[8] Muthukrishnan R and Radha M 2011 Edge detection techniques for image segmentation Int. J. Comput. Sci. Inf. Technol. 3 259
[9] Avlash M and Kaur L 2013 Performances analysis of different edge detection methods on road images Int. J. Adv. Res. Eng. Appl. Sci. 2 27–38
[10] Narendra V G and Hareesha K S 2011 Study and comparison of various image edge detection techniques used in quality inspection and evaluation of agricultural and food products by computer vision Int. J. Agric. Biol. Eng. 4 83–90
[11] Sharma P, Singh G and Kaur A 2013 Different techniques of edge detection in digital image processing Int. J. Eng. Res. Appl. 3 458–61
[12] Srinivas R and Panda S 2013 Performance analysis of various Filters for image noise removal in different noise Environment Int. J. Adv. Comput. Res. 3 47–52