Choosing the Quality of Two Dimension Objects by Comparing Edge Detection Methods and Error Analysis

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Abstract—**Choosing a quality image is the goal of image processing of two-dimensional (2D) images through computer vision. Image processing consists of stages, namely acquisition, pre-processing (enhancement), segmentation, representation and description, as well as introduction and interpretation. Edge detection is a stage in image processing that aims to find the pattern of an image. This study analyzes the quality of 2D images through edge detection techniques with a comparison of various techniques and error analysis. The comparison of edge detection in this study was performed on images produced using some techniques, such as Canny, Sobel, Prewitt, and Roberts. To analyze the error, Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) were used. This study was conducted using Matlab by comparing six different images of lung, car, leaf, apple, cat, and motorcycle. The results show that using edge detection with the Canny technique may result in the best MSE and PSNR values. Consistent results of six images detected also show that Canny technique produced the best MSE and PSNR values among the results produced by the Sobel, Prewitt, and Roberts techniques.**

Index Terms—**Comparison, error, edge detection, 2D, image**

I. Introduction

IMAGE processing is one of the interesting topics in the field of computer vision. It is commonly done through some stages, namely, acquisition, pre-processing (enhancement), segmentation, representation and description, as well as introduction and interpretation. Edge detection is a stage in image processing that aims to find an image pattern.

Edge detection is a fundamental problem in computer vision and image processing [1-4]. Meanwhile, angle detection is a major problem in image segmentation [5-9]. The purpose of image segmentation is to partition an image into meaningful regions so that the edges on a digital image become areas with strong intensity contrast and the surge in intensity from one pixel to the next pixel. In a study on computer vision and image processing systems to interpret images, the first step is to detect the edge of each object in the image [10-14]. In performing edge detection on digital imagery, there are several operating techniques including image segmentation and object boundary extraction. Each technique is designed to be sensitive to certain types of edges. The techniques are Canny, Sobel, Roberts, Prewitt, and Laplacian of Gaussian (LoG), but Canny is the most widely used technique.

The geometry of the technique determines the direction of the characteristics that are most sensitive to the edges. The appearance of noise in image segmentation is a problem that has to be addressed. Images are very vulnerable to being affected by noise which has many variations, such as Rayleigh Noise, Bitnik Noise, Gaussian Noise, and Impulse Noise. Previous studies have found that edge detection using Canny has proven to be the best technique in the segmentation and localization of object boundaries among other techniques such as Sobel, Roberts, Prewitt, and LoG [15-17].

The purposes of detecting edges are to group objects in an image and to further analyze the image [18-20]. Edge detection is divided into two groups, namely first-order edge detection and second-order edge detection [13]. First-order edge detection works using first-order derivatives or differentials. Techniques that belong to the first order are Sobel, Prewitt, Robert, and Canny, while the second order detection employs a second-order derivative, namely LoG [22].

Canny edge detection technique is an edge detection method that will produce a different image display from all methods because it displays the relief effect present in it [23]. Canny is a method used with the convolution approach of image functions with gaussian techniques and their derivatives [24]. The advantages of Canny technique are the ability to reduce noise before doing edge calculations so that there will be more numbers of resulting edges. Canny edge

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detection can detect actual edges with minimum error rates but optimal edges [25, 26].

Sobel is one of the techniques developed from Robert's method. This technique employs a High Pass Filter (HPF) that is set to single zero as a buffer [15, 20]. Sobel is an edge detection method that is included in the gradient edge detector. The algorithms include those that serve as image filters. This edge detection technique is an technique that uses a 3 x 3 neighbor matrix with the point being examined as the midpoint of the matrix [17, 27]. Sobel techniques are applied in two mask matrices; the $n \times n$ matrix that is the same as the neighbor matrix.

Roberts edge detection technique is a gradient-based edge detection technique using two kernels measuring 2 × 2 pixels [19]. Robert technique is also called the cross technique because of the x and y diagonal direction in quadrant 1 [20]. Robert’s techniques take diagonal directions for directional determination and look for differences in the horizontal direction and vertical differences, with added binary conversion process [20].

Prewitt edge detection technique is the development of Robert's method that employs the High Pass Filter (HPF) with a single zero buffer. Prewitt has a gradient equation similar to Sobel but with a constant value equal to 1 [21]. Prewitt's technique takes the principle of the Laplacian function of generating HPF. Prewitt edge detection is done partially in the opposite direction to the direction of the first derivative function and is the combined result of convolution of the Prewitt gradient in the x and y directions.

Previous studies on edge detection as object recognition of digital image, among others, focused on image input on Sobel, Canny, and Laplace edge detection techniques. Edge detection testing was conducted by considering the conversion speed of an object that affects the variation of the image, image resolution, image format, camera specifications, and laptop specifications used. The results showed that Canny edge detection method was more effective because the resulting output was more detailed and clearer, and the execution time was faster compared to other techniques.

In another study, Matlab GUI was used in facial pattern recognition [21]. The Canny edge detection method was used to detect all edges or lines of a surface object. The Canny method was used because it could reduce noise before edge detection calculations were performed. Detection was carried out to perform facial recognition so that it could distinguish between facial patterns and other patterns. The results showed that Canny method obtained results by calculating gradient values and horizontal and vertical orientation directions. Studies show that Canny edge detection techniques were better than Sobel techniques because Canny techniques detected the actual edge and did not eliminate the actual edge. Meanwhile, the Sobel technique had an actual edge that was missing and brought up an edge that was not the actual edge. Studies on image processing show that Sobel techniques could produce thicker edges than Canny techniques.

This present study conducted a comparative analysis of edge detection methods using 2D objects. The edge detection comparison was done using four techniques, namely Sobel, Prewitt, Robert, and Canny algorithms. Edge detection was conducted as an initial stage in object recognition/tracking to be used in the next image processing process. The process of comparing edge detection was conducted using the Simulink Matlab tools. The results of image edge detection were then compared using a simulation of parameters of each algorithm. The results were used to examine the thickness and accuracy of parameters in detecting object edges. It was expected the shape of the object became clearer.

In order to examine the image quality through noise and error influences in the image segmentation process, it was necessary that random statistical size was used. A statistical measure could be used to characterize image input textures using Peak Signal-to-Noise Ratio (PSNR) and Mean Square Error (MSE). The purposes of this study were to compare different edge detection techniques and analyze the performance of each edge detection technique through error comparison. This study had proven that the six images consistently showed that Canny technique was the best technique for the edge detection process as it produced the highest error value among Sobel, Prewitt, and Roberts techniques.

Previous studies conducted similar stages, but they used one image and one or two detector techniques. The contribution of this study is the results of comparing a wide variety of detector techniques on edge detection to segment with six different images. This study has proven validly that Canny technique detector is the best detector for performing angle detection in 2D images. The results of this study are in line with the results of the previous study conducted by Pinaki [28, 29].

This study also consistently compared error values using MSE and PSNR for six images in grayscale as well as red, green, and blue (RGB) images. Grayscale and RGB images show that the Canny technique produces the best MSE values among Sobel, Prewitt, and Roberts techniques.

II. Comparison 2D Images

In this study, image processing and error examination were conducted according to the flowchart shown in Figure 1. In the image process, it is shown that the first stage was to select the color image and input it to Matlab to continue processing. In the next stage, the images were converted into the grayscale format. In general, the grayscale images contain two colors, namely white and black. Moreover, the grayscale image showed that white had the highest or strongest intensity while black indicated low or weak intensity. In the last stage, various edge detection techniques were employed to detect objects and edge limitations. The study detected six images, namely lung, car, leaf, apple, cat, and motorcycle.

The data of this study were collected by examining images that were used as edge detection objects. This study was conducted by referring to several journal articles related to object edge detection. The next stage was to learn the tools used in the edge detection algorithms namely Canny, Sobel, Prewitt, and Robert. Then, the researchers worked on the tools used in Simulink and Matlab for the edge detection process in the Matlab library. This study was conducted by applying the algorithms by Canny, Sobel, Prewitt, and Robert to detect the object edges. Edge detection was conducted by comparing the thick and thin edge lines resulting from each object.

Analysis of the effectiveness of edge detection was carried out by comparing error values using MSE and PSNR. The stages conducted in this study are (1) manually converting images using photoshop into black and white images, (2) finding an image edge detection using Canny, Sobel, Prewitt, and Robert Edge Detection, and (3) using a mathematical approach, analyzing MSE and PSNR in Matlab by comparing manual image conversion with edge detection methods performed. Furthermore, through MSE and PSNR analysis, the edge detection techniques that obtained the smallest number of errors were identified. With the least number of errors, the results of digital image processing through edge detection will make the processing image more accurate when compared to the original image.

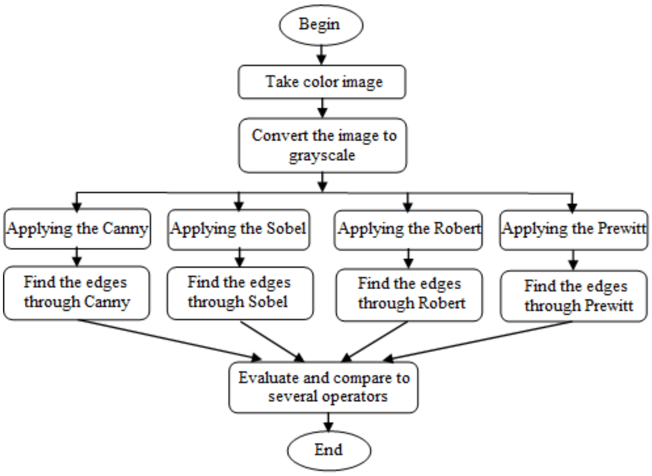


Fig 1. Flowchart for Image Processing with edge detection

The analysis in this study was done by means of the performance evaluation techniques by examining MSE and PSNR values in order to find out which methods were better to use in improving image quality. In a digital image, there is a standard measurement for image quality error, namely MSE and PSNR values. The success rate and quality of an image quality improvement method were calculated using MSE and PSNR. The ability of the method to improve image quality can also be measured using visual techniques by looking at the results and comparing them with the original images. However, for medical images, it is hard to see the abnormalities without having sufficient knowledge. Thus, visual techniques may produce various results.

PSNR is a calculation that determines the value of an image processing result. The value of PSNR is determined by the magnitude or MSE value in the image. The greater value of PSNR represents better results shown in the display of the resulting image. Conversely, the smaller PSNR value, represents worse results of the detected image. The unit of in PSNR is the same as MSE, namely decibel (dB).

It is shown that when the PSNR values increase, the MSE will decrease. PSNR is commonly used to measure image quality in an image rearrangement. It is easier to define with MSE. MSE is the average squared error. The MSE value is obtained by comparing the difference values of the pixels of the original image and the resulted images at the same pixel. Increasing the MSE value may result in a worse display on the resulting image. Conversely, decreasing the MSE value may result in a better display of the resulting image.

Moreover, the collected data were analyzed using the mathematical approaches of MSE and PSNR using the following formula.

$$MSE = \left(\frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left(g'(x,y) - g(x,y)\right)^2 \right) \quad (1)$$

$$PSNR = 20log10(\frac{2^n}{MSE}) \quad (2)$$

x = the size of the image row
y = the size of the image column

$g(x,y)$= the matrix of image processing results

$[MN]$= the image size and n is bit/pixel

III. Findings and Discussions

This study compared four edge detection algorithms namely Canny, Sobel, Prewitt, and Robert edge detection algorithms. Edge detection in this study was used to recognize two-dimensional (2D) objects. The six images used in this study are the images of lungs, a car, a leaf, an apple, a cat, and a motorcycle as shown in figures 2, 3, 4, 5, 6, and 7 respectively. The parameters used in simulations for source block parameters and function block parameters are presented in Tables 1 to 8. The results obtained in the comparative study of four algorithms are the analysis of grayscale and Red, Green, Blue (RGB) images.

Edge detection is the first step in boundary extraction and objects recognition. It becomes very important to know the difference in performance among different types of edge detection techniques. This study was conducted to review edge detection techniques based on discontinuity intensity levels. The six images were examined using MATLAB software.

It was found that Canny edge techniques produce higher accuracy in detecting object edges through smaller MSE and higher PSNR values compared to other images resulted by other techniques namely Sobel, Prewitt, and Roberts. The relative performance of various edge detectors is also analyzed. Several detection techniques are selected to perform edge detection and image segmentation. The edge detection techniques selected in this study are Canny, Sobel, Prewitt, and Roberts. The original segmented images are shown in Figures 2, 3, 4, 5, 6, and 7 each showing the images of lungs, a car, a leaf, an apple, a cat, and a motorcycle. This section also describes the performance comparison of MSE and PSNR for each grayscale and RGB image presented in Tables 1, 2, 3, 4, 5, 6, 7, and 8.

The Peak-Signal-to-Noise Ratio (PSNR) is the ratio between the maximum possible strength of the signal and the sound force that can damage and affect the fidelity of its representation. It is a logarithmic function of the top value of the image and the square of the error average. The PSNR performance is in the range of high values. It has been observed that Canny edge detectors produce higher accuracy in detecting the edges of objects with higher entropy performance through MSE and PSNR analysis compared to Sobel, Prewitt, and Roberts techniques.

In addition, Roberts edge detectors have minimum entropy performance through MSE and PSNR analysis compared to Canny, Prewitt, and Roberts detectors. Statistical analysis for all edge detectors is shown in Tables 1 to 8. Meanwhile, Figures 2 to 7 are the results of the experiment of this study with parameter simulations conducted such as Tables 1 to 8.

Figure 2 shows the processing image of a lung image consisting of an original image and images in grayscale format detected using Canny, Sobel, Prewitt, and Roberts techniques. It also shows scan of RGB with Canny, Sobel, Prewitt, and Roberts techniques. Figure 2(a) shows the original image of the lungs. Figures 2(b), 2(c), 2(d), and 2(e) show the segmentation of images of the lungs in Grayscale using Canny, Sobel, Prewitt, and Roberts techniques respectively. Figures 2(f), 2(g), and 2(h) show images of lungs in RGB detected using the Canny technique. Figures 2(i), 2(j), and 2(k) are images of the lungs in RGB detected using Sobel technique. Meanwhile, Figures 2(l), 2(m), and 2(n) are images of the lungs detected using Prewitt technique RGB. Then, figures 2(o), 2(p) and 2(q) show images of the lung in RGB detected using Roberts technique.

In the analysis of the lung image in grayscale format, it is clearly seen that the grayscale lung image shows that Figure 2(b), the result of edge detection using the Canny technique, produces much clearer images than other techniques. Meanwhile, Figure 2(e) is the most obscure grayscale lung image as a result of angle detection using Roberts detector. While Figure 2(d) appears much clearer than Figure 2(c), it shows that the edge detection results with the Prewitt detector are relatively better than the Sobel detector. Therefore, Canny detector can indicate the best image result of the grayscale lung image.

The results of this grayscale lung image analysis can be validated using data in Tables 1 and 2. Edge detection using Canny method is the best because the line morphology produced by this edge detection is more clearly visible on the edge of the image. It is also more clearly visible on the inside, and the edge of the image looks thick. The vertical and horizontal lines on the front of the object are very clear when compared to the Sobel, Prewitt, and Roberts edge detection methods.

Similar to grayscale lung image analysis, RGB shape images using Canny detectors show brighter image (shown in Figures 2(f), 2(g), and 2(h)) than images produced by other detectors. Meanwhile, the RGB-shaped lung image detected using Roberts' detector shows the darkest images (see Figures 2(o), 2(p), and 2(q)) among images detected using other techniques. Prewitt RGB detector (shown in Figures 2(l), 2(m), and 2(n)) shows brighter results than Sobel detectors (Figures 2(i), 2(j), and 2(k)). It can be concluded that Canny detectors can detect RGB images more clearly than other detectors. RGB-shaped of lung image analysis results can be validated with data in Tables 3 to 8.

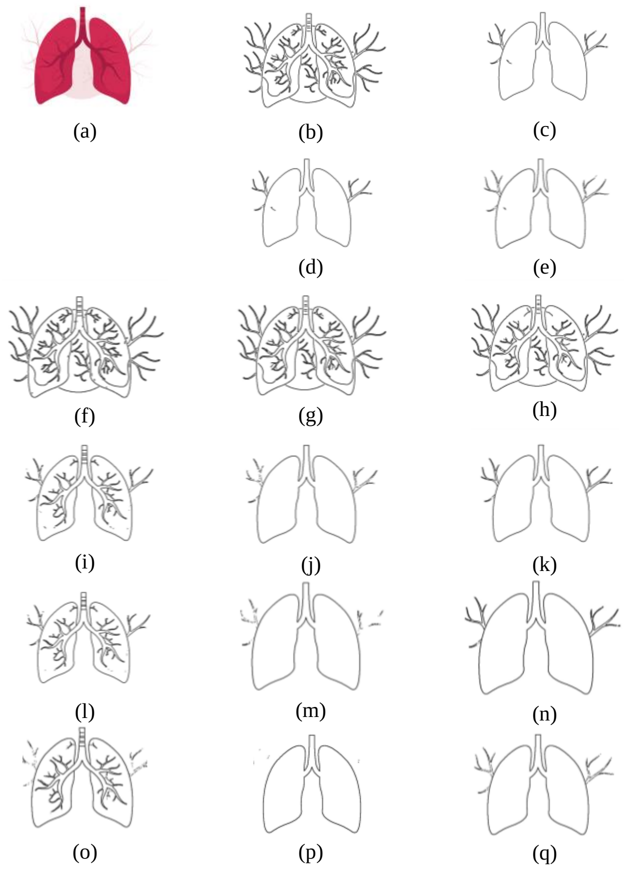


Fig 2. (a) Lung (original image), (b) Grayscale-Canny, (c) Grayscale-Sobel, (d) Grayscale-Prewitt, (e) Grayscale-Roberts, (f) Red-Canny, (g) Green-Canny, (h) Blue-Canny, (i) Red-Sobel, (j) Green-Sobel, (k) Blue-Sobel, (l) Red-Prewitt, (m) Green-Prewitt, (n) Blue-Prewitt, (o) Red- Roberts, (p) Green- Roberts, (q) Blue- Roberts

Furthermore, Figure 3 presents a set of car images that consists of original image and Grayscale images detected by Canny, Sobel, Prewitt, and Roberts techniques. It also shows scans for RGB from techniques of Canny, Sobel, Prewitt, and Roberts. Figure 3(a) shows the original image of the car. Figures 3(b), 3(c), 3(d), and 3(e) show the segmentation of the car image with Grayscale using Canny, Sobel, Prewitt, and Roberts techniques respectively. Figures 3(f), 3(g), and 3(h) show images of a car in RGB by Canny technique. Figures 3(i), 3(j) and 3(k) are images of cars in RGB by the Sobel technique. Meanwhile, Figures 3(l), 3(m), and 3(n) are images of cars in RGB by Prewitt technique. Then, Figures 3(o), 3(p) and 3(q) show images of cars in RGB by Roberts technique respectively.

Based on the analysis of car images in grayscale format, it is clearly seen that the grayscale car image shows that Figure 3(b), the result of edge detection using the Canny detector produces a clearer image than other techniques. Meanwhile, Figure 3(e) is the most obscure grayscale car image as a result of edge detection using the Roberts technique. While Figure 3(d) appears clearer than Figure 3(c), it shows that the results of edge detection using Prewitt detectors are relatively better than those detected using Sobel detectors. However, the best result in the grayscale format of the car image is obtained by Canny technique. The results of this grayscale car image analysis can be validated with data presented in Tables 1 and 2.

Similar to grayscale car image analysis, RGB shape images using Canny detectors show a clearer image (Figures 3(f), 3(g), and 3(h)) than those processed using other techniques. Meanwhile, the RGB shape car image Roberts detector is the darkest (Figures 3(o), 3(p), and 3(q)) compared to other image resulted from other detection techniques. Meanwhile, the RGB car image of the Prewitt detector (Figures 3(l), 3(m), and 3(n)) shows brighter results compared to Sobel detectors (Figures 3(i), 3(j), and 3(k)). It can be concluded that Canny detectors can detect RGB images more clearly than other detectors. RGB car image analysis results can be validated using data in Tables 3 to 8.

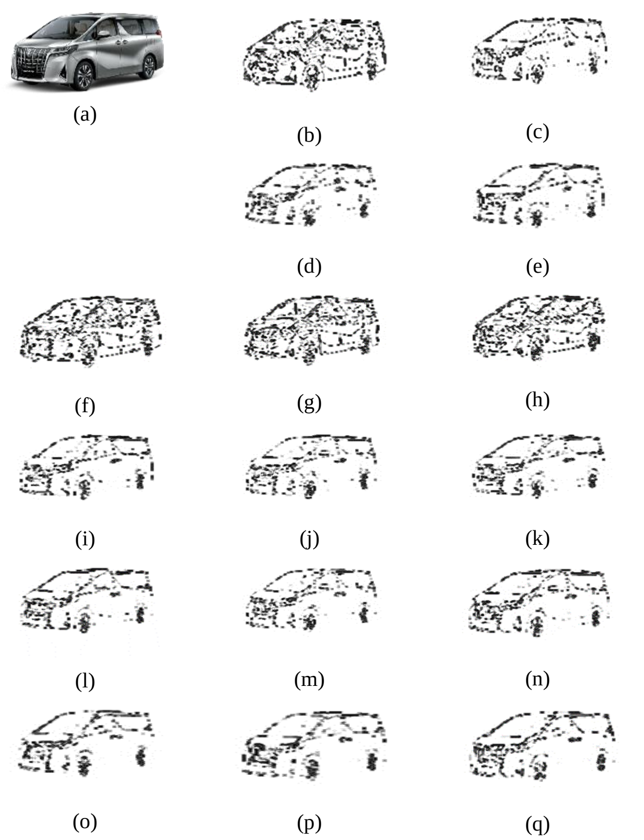


Fig 3. (a) Car (original image), (b) Grayscale-Canny, (c) Grayscale-Sobel, (d) Grayscale-Prewitt, (e) Grayscale-Roberts, (f) Red-Canny, (g) Green-Canny, (h) Blue-Canny, (i) Red-Sobel, (j) Green-Sobel, (k) Blue-Sobel, (l) Red-Prewitt, (m) Green-Prewitt, (n) Blue-Prewitt, (o) Red- Roberts, (p) Green- Roberts, (q) Blue- Roberts

Subsequently Figure 4 shows the leaf image consisting of original image and Grayscale images detected using Canny, Sobel, Prewitt, and Roberts techniques. It also shows scans for RGB with techniques of Canny, Sobel, Prewitt, and Roberts. Figure 4(a) shows the original image of a leaf. Figures 4(b), 4(c), 4(d), and 4(e) show the segmentation of leaf images in Grayscale using Canny, Sobel, Prewitt, and Roberts techniques respectively. Figures 4(f), 4(g), and 4(h) show images of the leaf in RGB from the Canny technique respectively. Figures 4(i), 4(j), and 4(k) are images of a leaf with RGB from the Sobel technique respectively. Meanwhile, Figures 4(l), 4(m), and 4(n) are leaf images in RGB from Prewitt technique. Figures 4(o), 4(p) and 4(q) show images of a leaf in RGB from Roberts technique respectively.

Based on the analysis of leaf images in grayscale form, it is clearly seen that the grayscale leaf image shows that Figure 4(b), the result of edge detection using the Canny detector, produces a clearer image than other detectors. Meanwhile, figure 4(e) is the most obscure grayscale leaf image as a result of edge detection using the Roberts detector. As Figure 4(d) appears clearer than Figure 4(c), it shows that the results of edge detection with the Prewitt detector are relatively better than those resulted from the Sobel detector. However, the best results in the grayscale format of leaf images are obtained by Canny detector. The results of this grayscale leaf image analysis can be validated using the data in presented Tables 1 and 2.

Similar to the grayscale leaf image analysis, RGB shape images by Canny detectors produce clearer images (Figures 4(f), 4(g), and 4(h)) than other techniques. Meanwhile, the RGB leaf image by Roberts detector shows the darkest images (Figures 4(o), 4(p), and 4(q)) among other techniques. Then, the RGB leaf image of the Prewitt detector (Figures 4(l), 4(m), and 4(n)) shows brighter results compared to the Sobel detector (Figure 4(i), 4(j), and 4(k)). It can be concluded that Canny detectors can produce clearer RGB images than other detectors. The RGB of leaf image analysis results can be validated using the data in Tables 3 to 8.

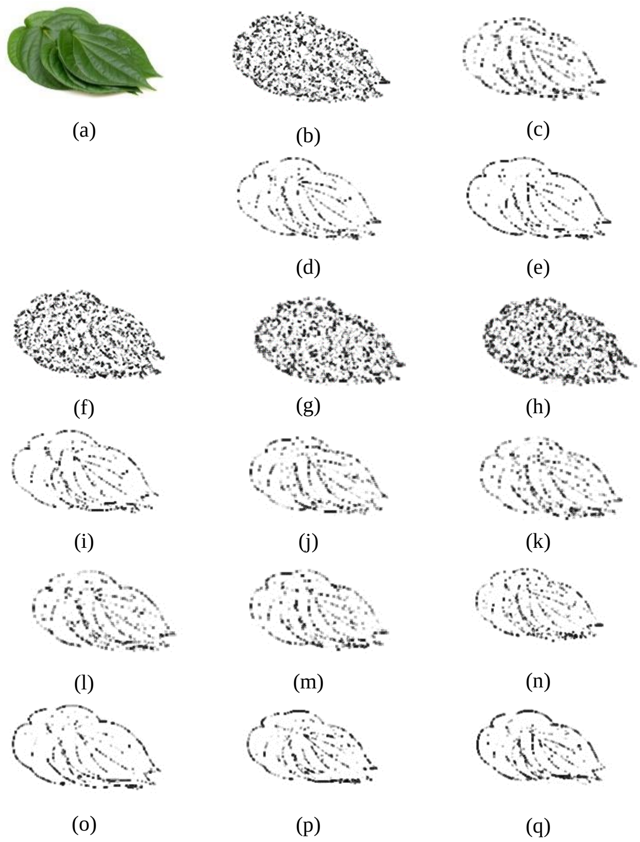
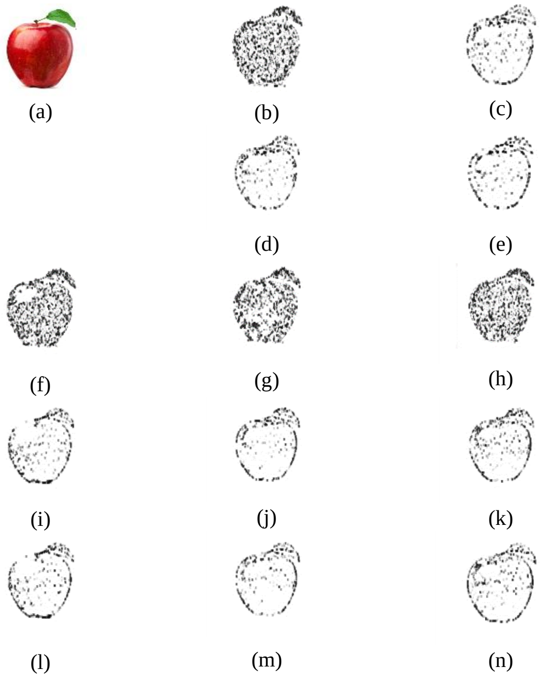


Fig 4. (a) Leaf (original image), (b) Grayscale-Canny, (c) Grayscale-Sobel, (d) Grayscale-Prewitt, (e) Grayscale-Roberts, (f) Red-Canny, (g) Green-Canny, (h) Blue-Canny, (i) Red-Sobel, (j) Green-Sobel, (k) Blue-Sobel, (l) Red-Prewitt, (m) Green-Prewitt, (n) Blue-Prewitt, (o) Red- Roberts, (p) Green- Roberts, (q) Blue- Roberts

In addition, Figure 5 shows a set of apple images that consist of an original image and Grayscale images produced by Canny, Sobel, Prewitt, and Roberts techniques. It also shows scans of RGB from Canny, Sobel, Prewitt, and Roberts techniques. Figure 5(a) shows the original image of the apple. Figures 5(b), 5(c), 5(d), and 5(e) show the segmentation of apple images in Grayscale produced by Canny, Sobel, Prewitt, and Roberts techniques respectively. Figures 5(f), 5(g), and 5(h) show images of a leaf in RGB from Canny technique. Figures 5(i), 5(j) and 5(k) are images of a leaf in RGB from the Sobel technique. Meanwhile, Figures 5(l), 5(m), and 5(n) are apple images in RGB from Prewitt technique. Then, Figures 5(o), 5(p) and 5(q) show images of a leaf in RGB from Roberts technique.

Based on the analysis of the apple images in grayscale, it is clearly seen that the grayscale apple image shown in Figure 5(b), the result of edge detection using the Canny detector, produces a clearer image than those produced by other detectors. Meanwhile, figure 5(e) is the most obscure grayscale apple image as a result of edge detection using the Roberts detector. While Figure 5(d) appears clearer than Figure 5(c), it shows that the results of edge detection with the Prewitt detector are relatively better than those resulted by Sobel detector. However, the best result in the grayscale of the apple image is obtained by Canny detector. The results of this grayscale apple image analysis can be validated using the data in Tables 1 and 2.

Similar to grayscale apple image analysis, RGB images produced by Canny detectors show better image clarity (Figures 5(f), 5(g), and 5(h)) than the images detected using other techniques. Meanwhile, Roberts detector produces the darkest image (Figures 5(o), 5(p), and 5(q)) among other techniques. Meanwhile, the RGB apple image from Prewitt detector (Figures 5(l), 5(m), and 5(n)) shows brighter results compared to Sobel detectors (Figures 5(i), 5(j), and 5(k)). It can be concluded that Canny detector can produce RGB clearer images than other detectors. The analysis results of RGB images are shown in Tables 3 to 8.



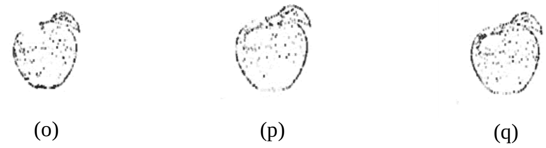
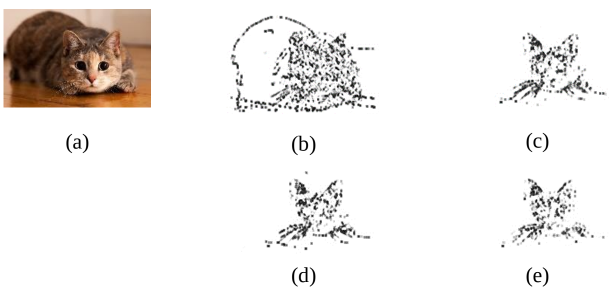


Fig 5. (a) Apple (original image), (b) Grayscale-Canny, (c) Grayscale-Sobel, (d) Grayscale-Prewitt, (e) Grayscale-Roberts, (f) Red-Canny, (g) Green-Canny, (h) Blue-Canny, (i) Red-Sobel, (j) Green-Sobel, (k) Blue-Sobel, (l) Red-Prewitt, (m) Green-Prewitt, (n) Blue-Prewitt, (o) Red-Roberts, (p) Green- Roberts, (q) Blue- Roberts

Figure 6 presents a set of cat images consisting of the original image and Grayscale images produced by Canny, Sobel, Prewitt, and Roberts techniques. It also shows scans for RGB from Canny, Sobel, Prewitt, and Roberts techniques. Figure 6(a) shows the original image of the cat. Figures 6(b), 6(c), 6(d), and 6(e) show the segmentation of the cat in Grayscale using Canny, Sobel, Prewitt, and Roberts techniques respectively. Figures 6(f), 6(g), and 6(h) show images of a cat in RGB from the Canny technique respectively. Figures 6(i), 6(j), and 6(k) are images of cats in RGB from Sobel technique respectively. Meanwhile, Figures 6(l), 6(m), and 6(n) are images of a cat in RGB from Prewitt technique respectively. Figures 6(o), 6(p), and 6(q) show images of a cat with RGB from Roberts technique respectively.

Analysis of cat images in grayscale. It is clearly seen that the grayscale cat image shows that Figure 6(b), the result of edge detection using the Canny detector shows a clearer image than other techniques. Meanwhile, figure 6(e) is the most obscure grayscale cat image resulted from the edge detection using the Roberts technique. While Figure 6(d) appears clearer than Figure 6(c), it shows that the results of edge detection with Prewitt detector are relatively better than those of Sobel detectors. However, the best result in the grayscale cat image is obtained by Canny technique. The results of this grayscale cat image analysis can be validated from the data presented in Tables 1 and 2.

Similar to the grayscale cat image analysis, RGB images using Canny detectors show brighter images (Figures 6(f), 6(g), and 6(h)) than images resulted by other techniques. Meanwhile, the RGB shape cat image obtained from Roberts detector shows the darkest images (Figures 6(o), 6(p), and 6(q)) of all images resulted from other techniques. Meanwhile the RGB cat image of the Prewitt detector (Figures 6(l), 6(m), and 6(n)) shows brighter results compared to Sobel detectors (Figures 6(i), 6(j), and 6(k)). It can be concluded that Canny detector can detect RGB images better than other detectors. The results of RGB cat image analysis are presented in Tables 3 to 8.



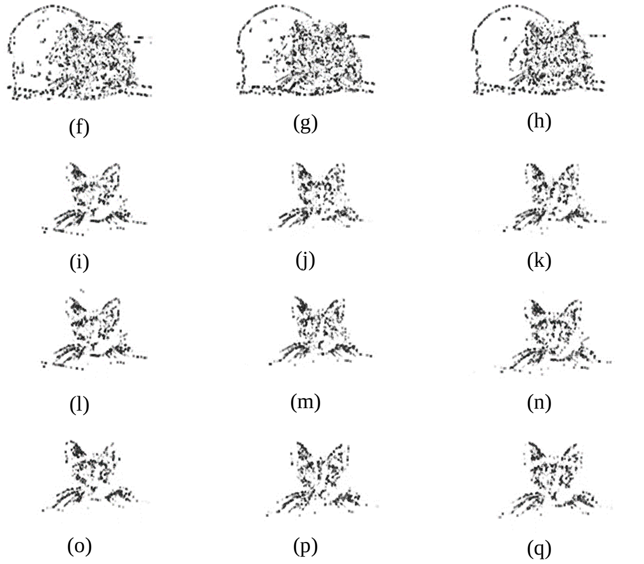


Fig 6. (a) Cat (original image), (b) Grayscale-Canny, (c) Grayscale-Sobel, (d) Grayscale-Prewitt, (e) Grayscale-Roberts, (f) Red-Canny, (g) Green-Canny, (h) Blue-Canny, (i) Red-Sobel, (j) Green-Sobel, (k) Blue-Sobel, (l) Red-Prewitt, (m) Green-Prewitt, (n) Blue-Prewitt, (o) Red- Roberts, (p) Green- Roberts, (q) Blue- Roberts

Hereinafter, Figure 7 presents a set of motorcycle images that consist of the original image and Grayscale images from Canny, Sobel, Prewitt, and Roberts techniques. It also shows the scans for RGB from techniques of Canny, Sobel, Prewitt, and Roberts. Figure 7(a) shows the original image of the motorcycle. Figures 7(b), 7(c), 7(d), and 7(e) show the segmentation of the motorcycle in Grayscale from Canny, Sobel, Prewitt, and Roberts techniques respectively. Figures 7(f), 7(g), and 7(h) show images of a motorcycle in RGB from the Canny technique. Figures 7(i), 7(j), and 7(k) are images of a motorcycle in RGB produced by Sobel technique. Meanwhile, Figures 7(l), 7(m), and 7(n) are images of a motorcycle in RGB produced by Prewitt technique. Then, figures 7(o), 7(p) and 7(q) show images of a motorcycle in RGB produced by Roberts technique.

From the analysis of motorcycle images in grayscale, it is clearly seen that Figure 7(b), the result of edge detection using the Canny detector, shows the clearest image. Meanwhile, figure 7(e) is the most obscure grayscale motorcycle image resulted from edge detection using the Roberts technique. Figure 7(d) looks clearer than Figure 7(c). It shows that the results of edge detection using Prewitt detectors are relatively better than those resulted from Sobel detectors. However, the best result in the grayscale shape of a motorcycle is obtained by Canny technique. The results of this grayscale motorcycle image analysis are presented in Tables 1 and 2.

Similar to the grayscale motorcycle image analysis, RGB shape images produced by Canny detectors show brighter clearer images (Figures 7(f), 7(g), and 7(h)) than those produced by other techniques. Meanwhile, the RGB motorcycle image from Roberts detector shows the darkest images (Figures 7(o), 7(p), and 7(q)) of all images produced by other techniques. Meanwhile, the RGB motorcycle images of the Prewitt detector (Figures 7(l), 7(m), and 7(n)) show brighter results compared to images produced by Sobel detectors (Figures 7(i), 7(j), and 7(k)). It can be concluded that Canny detectors can detect RGB images better, thus resulting in clearer images than other detectors. The RGB motorcycle image analysis results are presented in Tables 3 to 8.

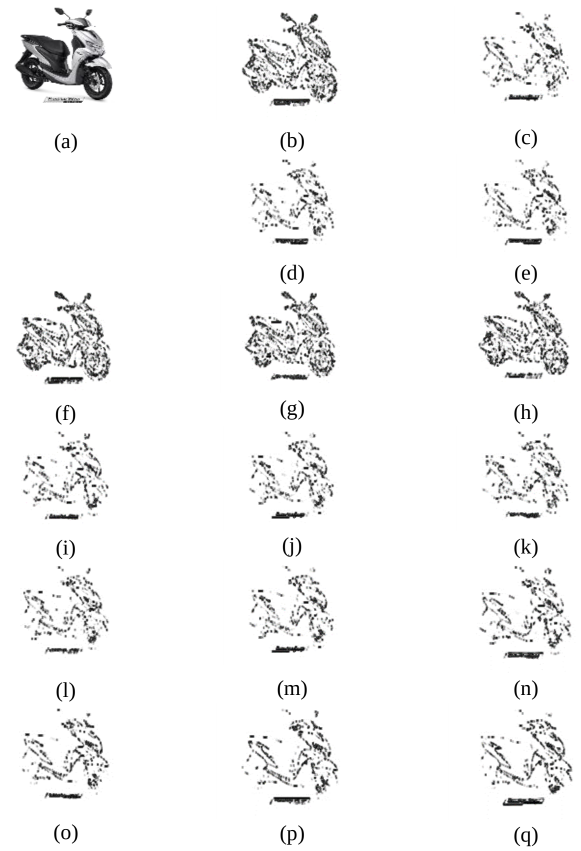


Fig 7. (a) Motorcycle (original image), (b) Grayscale-Canny, (c) Grayscale-Sobel, (d) Grayscale-Prewitt, (e) Grayscale-Roberts, (f) Red-Canny, (g) Green-Canny, (h) Blue-Canny, (i) Red-Sobel, (j) Green-Sobel, (k) Blue-Sobel, (l) Red-Prewitt, (m) Green-Prewitt, (n) Blue-Prewitt, (o) Red-Roberts, (p) Green- Roberts, (q) Blue- Roberts

In order to validate the relative performance results of each edge detection technique, an analysis was carried out using MSE and PSNR. Tables 1 to 8 show the results of MSE and PSNR analysis for Canny, Sobel, Prewitt, and Roberts techniques in the six images used in this study.

Table 1 shows MSE analysis of six images in grayscale. The analysis using Canny techniques shows the smallest MSE values for the six images examined in this study. It is noted that MSE shows each image in the grayscale format and can produce the smallest MSE value using the edge detection technique of Canny technique. It means that Canny technique has relatively better performance than other techniques.

Meanwhile, MSE values resulted from Roberts techniques show the greatest value of all grayscale shape images in this study. This shows that Roberts technique has relatively poorer performance compared to other techniques. Meanwhile, the MSE value of images produced by Prewitt technique shows a smaller value for the analysis of all grayscale images compared to the Sobel technique. This shows that the Prewitt technique is better than the Sobel technique in relative performance.

TABLE 1
COMPARISON OF MSE VALUES FOR GRAYSCALE IMAGES

Images	MSE-Canny	MSE-Sobel	MSE-Prewitt	MSE-Roberts
Lung	0.6394e+03	0.7782e+3	0.7711e+03	1.0194e+03
Car	1.1201e+03	2.9932e+03	2.9723e+03	3.4719e+03
Leaf	1.6161e+03	3.3683e+03	3.7623e+03	3.9276e+03
Apple	1.8338e+03	2.0461e+03	2.0271e+03	2.2227e+03
Cat	1.5123e+03	3.5880e+03	3.5172e+03	3.7127e+03
Motorcycle	0.9419e+03	2.8168e+03	2.8052e+03	3.1067e+03

Table 2 shows PSNR analysis on six images in grayscale format. Using Canny techniques, the greatest PSNR values for the six images examined in this study are produced. PSNR examination shows that each image produced by Canny edge detection technique can produce the greatest PSNR value. This shows that Canny technique has relatively a better performance than other techniques.

Whereas, based on the results of the analysis, the PSNR value of images resulted from Roberts technique is the smallest of all the results of all grayscale shape image analysis in this study. This shows that Roberts technique has relatively poorer performance compared to other techniques. Meanwhile, the PSNR value of images produced using the Prewitt technique is greater compared to the image produced by Sobel technique. This shows that the Prewitt technique can perform better than the Sobel technique.

TABLE 2
COMPARISON OF PSNR VALUES FOR GRAYSCALE IMAGES

Images	PSNR-Canny	PSNR-Sobel	PSNR-Prewitt	PSNR-Roberts
Lung	20.0726	19.2198	19.2594	18.0474
Car	17.6384	13.3694	13.3999	12.7252
Leaf	16.0462	12.8567	12.3762	12.1895
Apple	15.4973	15.0215	15.0620	14.6620
Cat	16.3345	12.5823	12.6688	12.4339
Motorcycle	18.3904	13.6333	13.6511	13.2078

Table 3 shows the MSE analysis of six images in RGB in red color. Based on the analysis, it was found that Canny techniques produce the smallest MSE values of the six images examined in this study. It is noted that the smallest MSE value is obtained by the images produced by the edge detection technique of Canny technique. This shows that Canny technique has a better performance than other techniques.

Meanwhile, based on the results of the analysis of all RGB images in red color, images produced by Roberts techniques obtain the greatest MSE value. This shows that Roberts technique has relatively poorer performance compared to other techniques. Meanwhile, the MSE value of images obtained using the Prewitt technique for RGB in red color is smaller when compared to the values of images produced by Sobel technique. This shows the Prewitt technique is better than the Sobel technique in terms of relative performance.

TABLE 3
COMPARISON OF MSE VALUES FOR RGB FORM WITH THE COLOR OF RED

Images	MSE-Canny	MSE-Sobel	MSE-Prewitt	MSE-Roberts
Lung	0.4894e+03	0.8368e+03	0.8262e+03	1.2216e+03
Car	3.3629e+03	3.6312e+03	3.6225e+03	3.9915e+03
Leaf	1.5203e+03	3.2708e+03	3.2708e+03	3.6336e+03
Apple	1.7990e+03	1.7925e+03	1.7908e+03	1.9609e+03
Cat	1.6256e+03	3.7636e+03	3.7099e+03	3.9492e+03
Motorcycle	4.5532e+03	3.8220e+03	3.8054e+03	3.8275e+03

Table 4 shows the MSE analysis of six images in RGB format in green color. The images produced from Canny techniques have the smallest MSE values for the six images examined in this study. It is noted that the smallest MSE value is obtained by images produced by Canny technique. This shows that Canny technique has better performance than other techniques.

Then, based on the results of analysis of all RGB images in green color, images produced by Roberts technique obtain the greatest MSE value. This shows that Roberts technique has relatively poorer performance compared to other techniques. The MSE value of images obtained using the Prewitt technique for RGB form on green color is smaller when compared to the values of the images produced by Sobel technique. This shows that the Prewitt technique is better than the Sobel technique in terms of relative performance.

TABLE 4
COMPARISON OF MSE VALUES FOR RGB FORM WITH THE COLOR OF GREEN

Images	MSE-Canny	MSE-Sobel	MSE-Prewitt	MSE-Roberts
Lung	0.8227e+03	0.7501e+03	0.7635e+03	0.9579e+03
Car	5.2610e+03	4.3061e+03	4.3101e+03	4.3370e+03
Leaf	1.3946e+03	3.1390e+03	3.1415e+03	3.4732e+03
Apple	1,66E+07	1.4480e+03	1.4495e+03	1.5687e+03
Cat	1.5614e+03	3.5164e+03	3.4509e+03	3.7125e+03
Motorcycle	2.5816e+03	3.2467e+03	3.2320e+03	3.0510e+03

Table 5 shows the MSE analysis of six images in RGB in blue color. Based on the analysis, it was found that Canny techniques produce the smallest MSE values of the six images examined in this study. It is noted that the smallest MSE value is obtained by the images produced by the edge detection technique of Canny technique. This shows that Canny technique has better performance than other techniques.

Based on the results of the analysis of all RGB images in blue color, images produced by Roberts techniques obtain the greatest MSE value. This shows that Roberts technique has relatively poorer performance compared to other techniques. Meanwhile, the MSE value of images obtained using the Prewitt technique in RGB in blue color is smaller when compared to the values of the images produced by Sobel technique. This shows the Prewitt technique is better than the Sobel technique in terms of relative performance.

TABLE 5
COMPARISON OF MSE VALUES FOR RGB FORM WITH THE COLOR OF BLUE

Images	MSE-Canny	MSE-Sobel	MSE-Prewitt	MSE-Roberts
Lung	0.6768e+03	0.6039e+03	0.5968e+03	0.8378e+03
Car	4.3169e+03	4.1351e+03	4.1349e+03	3.7165e+03
Leaf	1.7330e+03	3.5162e+03	3.5171e+03	3.8654e+03
Apple	1.7424e+03	2.0220e+03	2.0171e+03	2.1637e+03
Cat	1.4871e+03	3.5161e+03	3.4623e+03	3.6981e+03
Motorcycle	3.8512e+03	3.6442e+03	3.6396e+03	3.8100e+03

Table 6 shows PSNR analysis of six images in RGB in red color. Based on the analysis, it was found that Canny techniques produces the smallest PPSNR values of the six images examined in this study. It is noted that the greatest PSNR value is obtained by the images produced by the edge detection technique of Canny technique. This shows that Canny technique has better performance than other techniques.

Based on the results of the analysis of all RGB images in red color, images produced by Roberts techniques obtain the greatest PSNR value. This shows that Roberts technique has relatively poorer performance compared to other techniques. Meanwhile, the PSNR value of images obtained using the Prewitt technique RGB in red color is smaller when compared to the values of the images produced by Sobel technique. This shows the Prewitt technique is better than the Sobel technique in terms of relative performance.

TABLE 6
COMPARISON OF PSNR FOR RGB FORM WITH THE COLOR OF RED

Images	PSNR-Canny	PSNR-Sobel	PSNR-Prewitt	PSNR-Roberts
Lung	21.2341	18.9042	18.9598	17.2615
Car	12.8636	12.5303	12.5407	12.1194
Leaf	16.3115	12.9842	12.9842	12.5275
Apple	15.5805	15.5961	15.6005	15.2062
Cat	16.0207	12.3748	12.4372	12.1657
Motorcycle	11.5477	12.3079	12.3268	12.3017

Table 7 shows PSNR analysis of six images in RGB on green color. Based on the analysis, it was found that Canny techniques produce the smallest PSNR values of the six images examined in this study. It is noted that the greatest PSNR value is obtained by the images produced by the edge detection technique of Canny technique. This shows that Canny technique has better performance than other techniques.

Based on the results of the analysis of all RGB images on green color, images produced by Roberts techniques obtain the smallest PSNR value. This shows that Roberts technique has relatively poorer performance compared to other techniques. Meanwhile, the PSNR value of images obtained using the Prewitt technique RGB on green color is greater when compared to the values of the images produced by Sobel technique. This shows the Prewitt technique is better than the Sobel technique in terms of relative performance.

TABLE 7
COMPARISON OF PSNR FOR RGB FORM WITH THE COLOR OF GREEN

Images	PSNR-Canny	PSNR-Sobel	PSNR-Prewitt	PSNR-Roberts
Lung	18.9780	19.3794	19.3023	18.3175
Car	10.9201	11.7899	11.7860	11.7589
Leaf	16.6863	13.1629	13.1595	12.7235
Apple	15.9424	16.5232	16.5185	16.1753
Cat	16.1957	12.6698	12.7515	12.4342
Motorcycle	14.0119	13.0163	13.0361	13.2864

Table 8 shows PSNR analysis of six images in RGB in blue color. Based on the analysis, it was found that Canny techniques produce the greatest PSNR values of the six images examined in this study. It is noted that the greatest PSNR value is obtained by the images produced by the edge detection technique of Canny technique. This shows that Canny technique has better performance than other techniques.

Based on the results of the analysis of all RGB images on green color, images produced by Roberts techniques obtain the smallest PSNR value. This shows that Roberts technique has relatively poorer performance compared to other techniques. Meanwhile, the PSNR value of images obtained using the Prewitt technique RGB on blue color is greater when compared to the values of the images produced by Sobel technique. This shows the Prewitt technique is better than the Sobel technique in terms of relative performance.

TABLE 8
COMPARISON OF PSNR FOR RGB FORM WITH THE COLOR OF BLUE

Images	PSNR-Canny	PSNR-Sobel	PSNR-Prewitt	PSNR-Roberts
Lung	19.8259	20.3208	20.3718	18.8994
Car	11.7791	11.9660	11.9661	12.4295
Leaf	15.7427	12.6700	12.6689	12.2589
Apple	15.7194	15.0730	15.0835	14.7788
Cat	16.4074	12.6702	12.7372	12.4510
Motorcycle	12.2749	12.5148	12.5203	12.3215

The MSE performances comparison refers to Tables 1, 3, 4, dan 5, it was found that Canny edge techniques produce higher accuracy in detecting object edges through smaller MSE values compared to other images resulted by other techniques namely Sobel, Prewitt, and Roberts. The relative performance of various edge detectors is also analyzed. Several detection techniques are selected to perform edge detection and image segmentation.

Meanwhile, the PSNR performances comparison refers to Tables 2, 6, 7, dan 8, it has been observed that Canny edge detectors produce higher accuracy in detecting the edges of objects with higher entropy performance through PSNR analysis compared to Sobel, Prewitt, and Roberts techniques.

This study examines the image quality through noise and error influences in the image segmentation process. This study had proven that the six images consistently showed that Canny technique was the best technique for the edge detection process as it produced the best error performances among Sobel, Prewitt, and Roberts techniques.

IV. CONCLUSION

Edge detection is the first step in object boundary extraction and object recognition. This stage is very important in detecting differences among techniques in the edge detection process. In this study, several techniques were implemented to review edge detection based on the intensity level of discontinuity. Relative performance comparisons of several techniques in edge detection for 2D images were done using MATLAB. Based on the results of the MSE and PSNR analysis, Canny technique is better than Sobel, Prewitt, and Roberts techniques as it produces higher accuracy in the edge detection. In addition, Canny technique performs better compared to other techniques because the line morphology produced by this edge detection is more clearly visible on the image edge. It is clearly visible on the inside, the edge of the image looks thick, and vertical and horizontal lines on the front of the object are very clear when compared to the images produced by Sobel, Prewitt, and Roberts techniques. Meanwhile, Roberts technique shows the worst relative performance compared to other techniques, and Prewitt technique shows better relative performance than the Sobel technique.

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