ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 5, May 2016

SIMULATIVE ANALYSIS OF EDGE DETECTION OPERATORS AS APPLIED FOR ROAD IMAGES

Sukhpreet Kaur[1], Jyoti Saxena[2] and Sukhjinder Singh[3]
[1]Research scholar, [2]Professsor and [3]Assistant Professor
[1,2,3] Department of Electronics & Communication Engineering
[1,2,3]Giani Zail Singh Campus College of Engineering & Technology, Bathinda-151001, Punjab (India)

***Abstract*: Edge detection means identifying the outline of an image. Edge is boundary between the main object and background. The purpose of edge detection in general is to significantly reduce the amount of data in an image. This paper presents simulative analysis of four edge detection operators namely Canny, Robert, Prewitt and LOG as applied to road images. The detected edges of road images are compared with their ground truth images. Metrics for measuring image quality of operators taken for this work include Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), Mean Difference and Maximum Difference. It is observed that canny edge detection operator performed better as compared to Prewitt, LOG and Robert edge detection operator in terms of MSE, PSNR and Mean Difference.**

***Index Terms* – Edge Detection, Ground Truth, Quality Metrics, Road Image**

I. INTRODUCTION

Edge detection refers to the process of identifying and locating sharp discontinuities in the images. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in an image [5].An edge is sharp change in intensity of an image. An edge is not a physical entity, just like a shadow. It is where the picture ends and the wall starts, where the vertical and the horizontal surfaces of an object meet.

In this paper several typical edge detection operators in digital image processing are theoretically analyzed, and are used for road edge detection. By comparing the simulation results of road edge detection, the better road test results can be gained [1]. The geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be optimized to look for horizontal, vertical, or diagonal edges. So, measurement of image quality is very important to numerous image processing applications.

The term ground truth refers to the process of gathering the proper objective data. Ground truth database allows image data to be related to real features and material on the ground more specifically, ground truth may refer to a process in which a pixel on a satellite image is compared to what is there in reality in order to verify the contents of the pixel on the image.

Road feature extraction is helpful to analyze the direction of the road extension and the specific location, size and speed of obstacles on the road. This paper presents an effective comparison of four edge detection operators based on various parameters such as PSNR, MSE, Mean difference and Maximum difference. The analysis is based on the capability of producing accurate edges to determine object boundaries. Rest of the paper is organized as follows: Edge detection operators are discussed in section II. Section III presents experimental setup for this work. Image quality metrics are described in section IV. Section V provides results with discussion. Conclusions are drawn in section VI.

II. EDGE DETECTION OPERATORS

Each edge detection operator have its own way to find edges in an image. The goal of every detector is to avoid false edges and detected edges should be close true edges [5]. Generally edge detection block finds the edges in an input image by approximating the gradient magnitude of the image. The block convolves the input matrix with the Prewitt, or Roberts's kernel. The block outputs two gradient components of the image, which are the result of this convolution operation. Alternatively, the block can perform a thresholding operation on the gradient magnitudes and output a binary image, which is a matrix of Boolean values. If a pixel value is 1, it is an edge[12].

In Canny and LOG method the Edge Detection block finds edges by looking for the local maxima of the gradient of the input image. It calculates the gradient using the derivative of the Gaussian filter. The Canny method uses two thresholds to detect strong and weak edges. It includes the weak edges in the output only if they are connected to strong edges. As a result, the method is more robust to noise, and more likely to detect true weak edges .The comparison is done on the four original road images and their ground reference images by applying following four operators.

- Robert edge detection operator
- Canny edge detection operator
- Prewitt edge detection operator
- LOG edge detection operator

A. Roberts Edge Detection Operator

Roberts operator which uses partial differential operators to find the edge is the simplest operator [1].According to the principle that any pair difference of mutually perpendicular direction can be used to calculate the gradient, the difference between two adjacent diagonal direction pixels is calculated. The template of the operator is shown in Fig.1.

1	0
0	-1

0	1
-1	0

Fig.1: The Convolution Template of Roberts Operator

Roberts's operator is the 2 × 2 operator template. It deals with a steep low-noise images best. However, the detected image is not smooth by using Roberts's operator, and three disadvantages are as follows [10]:

- It is very sensitive to noise.
- Partial edge detected is not continuous.

- Positioning accuracy is not high.

If edge detection of the image is completed by Roberts operator template, each point of the image is convoluted by the two templates. This operator is used to detect the diagonal edges and then are put together to find resultant edge. This operator highlights regions of high spatial frequency which often correspond to edges. It takes grayscale image as input to the operator and gives grayscale image as the output

B. Canny Edge Detection Operator

The algorithm runs in 5 separate steps:
1. Smoothing: Blurring of the image to remove noise.
2. Finding gradients: The edges should be marked where the gradients of the image has large magnitudes.
3. Non-maximum suppression: Only local maxima should be marked as edges.
4. Double thresholding: Potential edges are determined by thresholding.
5. Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

Canny operator is a relatively new edge detection operator, which has been widely used. The basic idea of Canny operator is to make the image gradient operation, and then to obtain the edge by finding a local maximum gradient magnitude of pixel. Gradient is calculated by the derivative of Gaussian filter [7]. Canny operator uses two thresholds to detect the strong edges and weak edges, and only if connected to the strong edges and the weak edges, the weak edges will be included in the output. According to the requirements of edge detection, canny operator defines the following three optimization criteria:

- High signal to noise ratio**:** The real edge is not missed, and inspection of non-edge points cannot be wrong. In other words, true edge points are identified by high probability while non-edge points are identified by low probability.
- Precise positioning performance**:** Detected edge point location is away from the actual edge positions recently.
- Correspondence between detection points and the edge points: Each real edge and the detected edge point has correspondence relationships.

It is a method to find edges by isolating noise from the image without affecting the features of the edges in the image and then applying the tendency to find the edges and the critical value for threshold [1]. Canny also suggested using operators with multiple widths to detect edges. The Canny algorithm can be used as an optimal edge detector based on a set of criteria which include finding the most edges by minimizing the error rate, marking edges as closely as possible to the actual edges to maximize localization, and marking edges only once when a single edge exists for minimal response [10].

C. Prewitt Edge Detection Operator

Prewitt operator is the first-order differential operator. It employs gray difference from top to bottom, left to right neighboring pixels to get the extreme edge [1]. The convolution template is shown in Fig.2.

-1	-1	-1
0	0	0
1	1	1

1	0	-1
1	0	-1
1	0	-1

Fig.2: Convolution Template of Prewitt Operator

Prewitt operator is the 3 × 3 operator template. Convolution of each pixel is carried out by the two templates. The maximum is selected as the point of an output value, and the result of operation is a range of image borders. It is one of the oldest and best understood methods of detecting edges in images [5].The prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. The prewitt operator is limited to 8 possible orientations, however most direct orientation estimates are not much more accurate. This gradient based edge detector is estimated in the 3x3 neighborhood for 8 directions [11].

D. LOG Edge Detection Operator

Laplace - Gaussian operator (usually referred to as the LOG operator) is the second-order differential operator. It will generate a steep zero-crossing in the edge of the image. In order to reduce the noise interference, the first step needs to use Gaussian function to filter the image, and then to obtain second-order derivative of the image [3]. The image is processed using Gaussian filter, and then image output is obtained by Laplacian operation (second-order differential operation). Laplacian operator is defined as in equation 1.1:

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \qquad (1.1)$$

In the process of edge detection, in order to simplify the calculation, the function of the LOG operator is achieved through the template [4]. LOG Laplace – Gaussian model has a basic requirement that template center coefficient is positive while the other adjacent coefficients are negative, and the sum of all coefficients should be zero [7].

LOG operator is the general process of filtering and differentiation for the image. The common template is shown in Fig.3.

0	-1	0
-1	4	-1
0	-1	0

-1	-1	-1
-1	8	-1
-1	-1	-1

Fig.3: Convolution Template of LOG Operator

III.EXPERIMENT SETUP

In this paper, performance of various edge detection operators Canny, Robert, Prewitt and LOG have been analyzed as applied to road images in terms of PSNR, MSE, Maximum Difference and Mean Difference Using MATLAB Platform.

Experimental setup for the same has been depicted in Fig. 4. The various steps have been summarized as follows:

Step 1: Input Road Image: Input any road image if it is in RGB then convert it into gray image

Step 2: Filtering: The gray image is filtered, filtering is commonly used to improve the performance of an edge detector with respect to noise. However, there is a trade-off between edge strength and noise reduction [6]. More filtering used to reduce noise results in a loss of edge strength.

Step 3: Binarization : Filtered image converted in binarization form which is in 1's and 0's form. Here 1's find edges in image and 0's elsewhere.

Step4: Enhancement: In order to facilitate the detection of edges, it is essential to determine changes in intensity in the neighborhood of a point.

Step 5: Detection: We only want points with strong edge content. However, many points in an image have a nonzero value for the gradient, and not all of these points are edges for a particular application. Therefore, some method should be used to determine which points are edge points. Frequently, thresholding provides the criterion used for detection.

Step 6: Localization: The location of the edge can be estimated with sub pixel resolution if required for the application. The edge orientation can also be estimated.

Step 7: Comparison: By applying different operators we get edges of image we compare this image with ground truth image with metrics. Comparison has been done between four objectives evaluations: pixel difference based measurement Peak Signal to Noise Ratio(PSNR), Mean Square

ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 5, May 2016

Error(MSE), Mean difference, Maximum difference by simulating them using MATLAB platform.

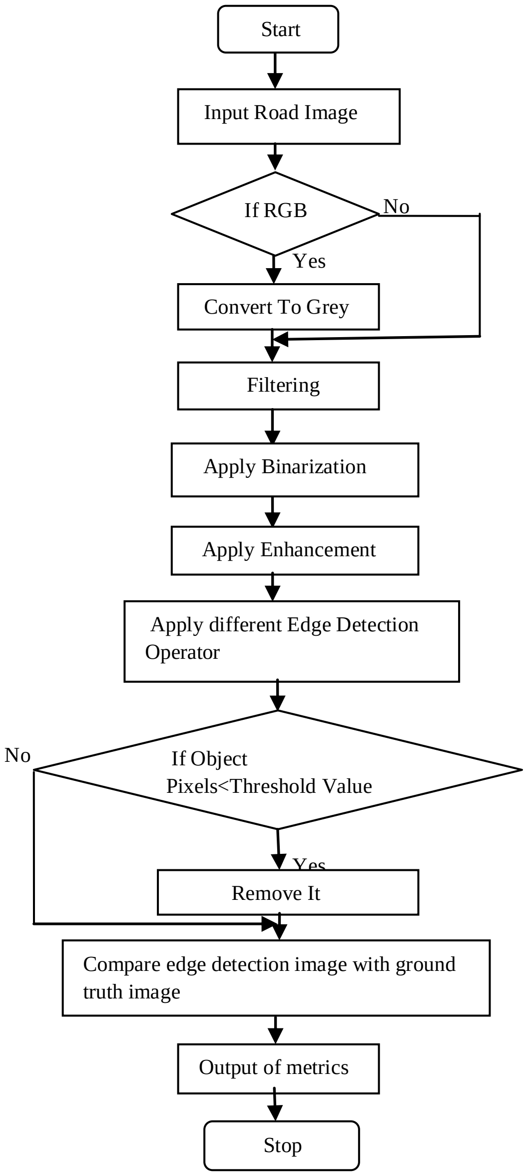


Fig.4. Experimental Setup

Following section summarized various image quality metrics taken for this work [2].

IV.IMAGE QUALITY METRICS

Image quality metrics can be classified according to the availability of an original (distortion-free) image, with which the ground truth image is to be compared. Well-known objective image quality metrics for measuring image quality taken for this work are as follows:

- Mean Squared Error (MSE)
- Peak Signal-to-Noise Ratio (PSNR)
- Maximum Difference
- Mean Difference

A. Mean Squared Error (MSE)

One obvious way of measuring image quality is to compute an error signal by subtracting the test signal from the reference, and then computing the average energy of the error signal [2]. The Mean-Squared-Error (MSE) is the simplest, and the most widely used image quality measurement. This metric is frequently used in signal processing and is defined in equation 1.2.

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\big(x(i,j)-y(i,j)\big)^2 \qquad (1.2)$$

Where $x(i,j)$ represents the original (reference) image and $y(i,j)$ represents the distorted (modified) image and i and j are the pixel position of the M*N image. MSE will be zero, for $x(i,j) = y(i,j)$. Large value of MSE means that the image is of poor quality.

B. Peak Signal-to-Noise Ratio (PSNR)

This is the most widely used objective image quality measure. The main advantage of this measure is ease of computation [2]. An important property of PSNR is that a slight spatial shift of an image can cause a large numerical distortion but no visual distortion and conversely a small average distortion can result in damaging visual artifacts, if all the error is concentrated in a small important region. This metric neglects global and composite errors PSNR can be calculated using Eq. (1.3),

$$PSNR = 10\log_{10}\frac{(2^n-1)^2}{\sqrt{MSE}} \qquad (1.3)$$

Where MSE is mean squared error. Larger PSNR indicate a smaller difference between the original (without noise) and reconstructed image .

C. Maximum Difference (MD)

MD is the maximum of the error signal (difference between the reference signal and test image) [8]. Large value of MD means that the image is of poor quality. Maximum difference (MD) can be calculated using equation (1.4).

$$MD = MAX\,|\,x(i,j) - y(i,j)\,| \qquad (1.4)$$

D. Mean Difference

Mean Difference is simply the mean of difference between the reference signal and test image. It is given by the equation 1.5.

$$Mean\ Difference = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\big(x(i,j)-y(i,j)\big) \qquad (1.5)$$

Where $x(i,j)$ represents the original (reference) image and $y(i,j)$ represents the distorted (modified) image and i and j are the pixel position of the M*N image. Large value of Mean difference means that the image is of poor quality[9].

The results of various edge detection operators as applied to road test images are represented in the following section.

V. RESULTS AND DISCUSSION

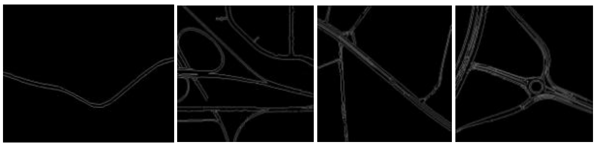
The different road images that are taken as test images to compare the performance of various edge detection operators. The images that are taken are shown in the Fig 5.

(a) (b) (c) (d)

Fig.5. Road Test Images

Fig.6 depicts the ground truth of above shown road test images to compare the quality of output road test images after applying various edge detection operators. In case of ground truth image, the edges are represented accurately. The actual ground truth image of original test images is shown in

Fig. 6. Different edge detection operators are implemented on the test images and compared with the actual ground truth images.



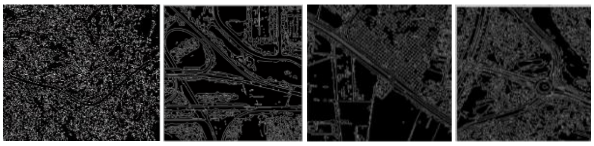
(a) (b) .(c) (d)

Fig.6. Ground Truth of Road Test Images

A. Canny Operator Output

Four test images are taken to compare with ground truth images. In case of Canny Edge Detection Operator, strong edges as well as weak edges are easier to detect in the output image.

The results of canny edge detection operator as applied on original road images, have been depicted in Fig 7.



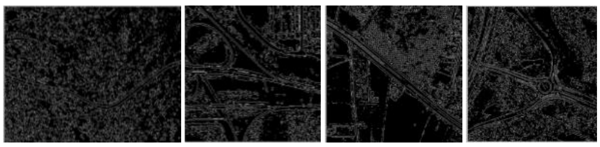
(a) (b) (c) (d)

Fig.7.Canny operator detection results

B. LOG Operator Output

In case of LOG Operator, the edge detection is not very accurate as compared to canny operator. But gives accuracy to decide the edge pixel whether it is transparent or dark zone.

After applying LOG edge detection operator to road images, output results are shown in Fig. 8.



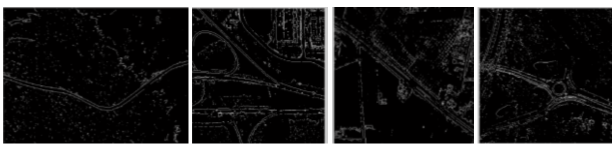
(a) (b) (c) (d)

Fig.8 LOG operator detection results

C. Prewitt Operators Output

In case of Prewitt operator, edges of the images are not accurate as compared to Canny Operator. In case of first test image, edges are more accurate as compared to other three.

The results of Prewitt edge detection operator as applied to road images, are represented in Fig. 9.



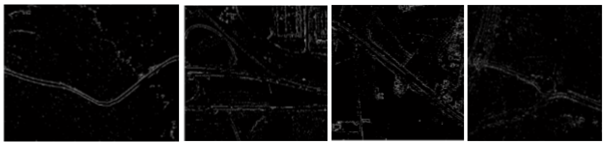
(a) (b) (c) (d)

Fig.9.Prewitt operator detection results

D. Robert Operator Output

The output ground truth images of Robert operator have lowest quality and positions of edges are not accurate.

The results of Robert's edge detection operator as applied to road test images, have been shown below (refer Fig 10).



(a) (b) (c) (d)

Fig.10. Robert operator detection results

From processing results of road images, it can be seen that canny and LOG operators obtain relatively good detection results. Edge detection results of Robert operators are worst as compared to other operators.

Table 1 shows MSE, PSNR, Maximum Difference and Mean Difference for different road test images as shown in fig. 5 (a). Different edge detection operators are implemented on these images and optimum operator is evaluated. It is observed from the table that Canny operator performed better as compared to other.

Table 1: Objective metrics for Canny, Robert, Prewitt and LOG edge detection operators as applied to road test image 5(a).

Metrics	Operator			
	Canny	**Robert**	**Prewitt**	**LOG**
MSE	9817	12974	12527	11657
PSNR	8.2110	7.0001	7.1523	7.4649
Max. Difference	156	141	143	147
Mean Difference	97.7562	112.7562	110.7562	106.7562

Table 2 shows result value for road test image 5(b).In this table canny, Robert, Prewitt and LOG operator show different values .which represent metrics values PSNR, Maximum Difference and Mean Difference .Results Shows good performance of Canny operator.

Table 2: Objective metrics for Canny, Robert, Prewitt and LOG edge detection operators as applied to road test image 5(b).

Metrics	Operator			
	Canny	Robert	Prewitt	LOG
MSE	9934	12919	12495	11671
PSNR	8.1596	7.0185	7.1634	7.4597
Max. Difference	156	141	143	147
Mean Difference	91.9904	106.904	104.9904	100.9904

Table 3 Shows metrics for different operators Canny, Robert, Prewitt and LOG edge detection operators for road test image 5(c). In this table different metrics give different values which show comparison of these operators.

Table 3: Objective metrics for Canny, Robert, Prewitt and LOG edge detection operators as applied to road test image 5(c)

Metrics	Operator			
	Canny	Robert	Prewitt	LOG
MSE	9910	12946	12515	11678
PSNR	8.1701	7.0094	7.1565	7.4571
Max. Difference	156	141	143	147
Mean Difference	93.6932	108.6932	106.6932	102.6932

Table 4: This table shows the values of PSNR, MSE, Maximum Difference and Mean Difference. Different edge detection operators are implemented on these images and optimum operator is evaluated..

Table 4: Objective metrics for Canny, Robert, Prewitt and LOG edge detection operators as applied to road test image 5(d).

Metrics	Operator			
	Canny	Robert	Prewitt	LOG
MSE	10011	12950	12532	11720
PSNR	8.1260	7.0081	7.1506	7.4415
Max. Difference	156	141	143	147
Mean Difference	90.4977	105.4977	103.4977	99.4977

Tables1-4: represent the edge detection operator's performance as applied for road test images as shown in fig. 5(a, b, c, d) Canny operator has less value of MSE than other operators which represent that canny operator has better edge detection quality then other. Less value of MSE means image has good quality. But in case of PSNR metrics high value means image has good quality. Again this value is maximum for Canny operator in each table. While, Maximum difference has high value and Mean Difference has less value in case of Canny operator.

V. CONCLUSIONS

Various edge detection operators such as Prewitt, LOG, Canny and Robert have been applied on four road test images using MATLAB platform. Their performance is examined using various objective image quality metrics such as PSNR (Peak Signal to Noise Ratio), MSE (Mean Square Error), maximum difference and mean difference. From the performance comparison of edge detection operators such as Prewitt, LOG, Canny and Robert, it is observed that Canny edge detection operator gives better performance than Prewitt, LOG and Robert edge detection operators in terms of MSE, PSNR and mean difference. After Canny edge detection operator, LOG edge detection operator gives larger value of PSNR, lesser values of MSE and mean difference which indicates LOG edge detection operator provides better edge detection than Robert edge detection operators. Moreover, Prewitt and Robert edge detection operators give poor performance as evaluated by MSE, PSNR and mean difference. However, give better values of maximum difference.

REFERENCES

[1] Chun-Ling Fan and Yuan-Yuan Ran, (2010), **"**Study on the Edge Detection Algorithms of Road Image**"** 3rd International Symposium on Information Processing, IEEE, pp.217-220.

[2] G. Gupta (2011), "Algorithm for Image Processing using Improved Median Filter and Comparison of Mean, Median and Improved Median filter'', International Journal of Soft Computing and Engineering, vol. 1, pp. 304-311.

[3] N.S. Chandrasekhar and K.R. Nataraj, (2012), "A Distributed Canny Edge Detector and its Implementation on FDGA", International Journal of Computational Engineering Research, vol. 2, pp. 177-181.

[4] Kiranjeet Kaur and Sheenam Malhotra, (2013), "A Survey on Edge Detection using Different Techniques", International Journal of Application or Innovation in Engineering and Management, vol. 2, pp. 496-500.

[5] A.Routray and K.B.Mohanty, (2007), "A Fast Edge Detection Algorithm for Road Boundary Extraction Under Non Uniform Light Condition'', Institute of Electrical and Electronics Engineers, vol. 10, pp. 38-40.

[6] P.Patidar, S.Srivastava, M.Gupta and A.K.Nagawat, (2010), "Image De-Noising by Various Filters for Different Noise", International Journal of Computer Applications, vol. 9, pp. 45-50.

[7] K.Zhang, S.Wang, and X.Zhang, (2002), "A New Metric for Quality Assessment of Digital Images based on Weighted Mean Square Error", Proceedings of Society of Photo-Optical Instrumentation Engineers, vol. 4875, pp. 1-6.

[8] K.Shilp and S.Aruna.Mastani, (2012), ''Comparison of Image Quality Metrics", International Journal Of Engineering Research & Technology vol.1 ,pp.1-6

[9] C.S.Varnan, A.Jagan, J.Kaur, D.Jyoti and D.S.Rao, (2011), "Image Quality Assessment Techniques pn Spatial Domain", International Journal of Computer Science and Telecommunications, vol. 2, pp. 177-184.

[10] B.Sirmacek and C.Unsalan, (2010), "Road Network Extraction using Edge Detection and Spatial Voting", International Conference on Pattern Recognition, pp. 3113-3116.

[11] Yoshiaki Honda,Koji Kajiwara and Yoshiaki Kimura, (1996),''Ground Truth Image Database for Global Scale Research", International Archives of Photogrammetric and Remote Sensing.vol.31,pp.290-296.

[12] M.Heath, S.Sarkar, T.Sanocki and K.Bowyery, (1998), "Comparison of Edge Detectors - A Methodology and Initial Study", Computer Vision And Image Understanding, vol. 69, pp. 38-54.