# An Overview of Various Edge Detection Techniques used in Image Processing

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**Abstract—This paper presents an effective comparison between various edge detection techniques. Edges represent the object boundaries and this way they are crucial for filtering of unnecessary data.This is the reason behind edge detection being an essential component in many computer image processing subfields such as classification, feature extraction, pattern recognition etc.We compare Morphological Gradient Edge Detector, Sobel edge detector and Laplacian of Gaussian edge detector. It is found that Sobel filter exhibits better results thanothers in terms of PSNR values.**

**Keywords—Morphological Gradient, Prewitts, Roberts, Laplacian of Gaussian.**

## I. INTRODUCTION

An edge may be the result of changes in light absorption, its shade, texture and color, and these changes can be used to determine the depth, size, positioning, alignment and surface properties of a digital image [1][6]. An edge is not only the boundary between an object and the background, but also the boundary between overlapping objects. In analyzing the image digitally, edge detection involves filtering extraneous and immaterial information to select the edge points. The detection of minute changes, which may be mixed up by noise, depends on the pixel threshold of change that defines an edge. Detection of such continuous edges is very strenuous and time consuming especially when an image is corrupted by noise [2].

Edge detection of an image reduces significantly the amount of data and filters out information that may be regarded as irrelevant, preserving the important structural properties of an image. Therefore, edges detected from the original image contain major information, which can be stored in a very less space than the original image, within the aid of edge map; the original image can be easily restored [13]. The main goal of the vision systems based on computational intelligence techniques is to achieve better edge detection when image processing is performed under high noise levels [2].This forms the basic requirement of comparing and selecting a technique which is insensitive to noise to a larger extent.

## II. VARIOUS EDGE DETECTION METHODS

It is crucial to have a good understanding ofedge detection method as edge detection is in the forefront of image processing for object detection. Various edge detection methods have been developed in the process of finding the perfect edge detector. Most of these detectors can be categorized as gradient based and laplacian based edge detectors.[10] Gradient based edge detectors use the method of looking for the maximum and the minimum in the first order derivative, then the obtained image is sharpened.This results in enhancement of fine details and blurred ones as well. The magnitude and the direction are then calculated.

### *A. Sobel Operator*

A simple directional mask wherein a 3x3 matrix is convoluted with the original image, It is characterized by equations (1), (2) and the masks are given by (3), (4).The magnitude is calculated using (5)[9].

$G_x = (a_2 + ca_3 + a_4)$-$(a_0 + ca_1 + a_6)$ *(1)*

$G_y = (a_0 + ca_1 + a_2)$-$(a_6 + ca_3 + a_4$ *(2)*

$$G_x = \begin{matrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{matrix} \quad (3)$$

$$G_y = \begin{matrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{matrix} \quad (4)$$

$$G = \sqrt{{G_x}^2 + {G_y}^2} \quad (5)$$

Compared to the other edge detectors,Sobel has two main advantages. One,It has smoothing effect on random noise. Two,it is the differential of two rows or two columns, so the elements of the edge on both sides has been enhanced,so that the edge seems thick and bright [4].But it is found that sobel operator is sensitive to noise [3][13]

*B. Laplacian of Gaussian*

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. It highlights regions of rapid intensity change and is therefore often used for edge detection.[7] Usually called the Log-operator, it is a second order derivative wherein it uses the zero crossings from the second order to detect edges. The Laplacian is often applied to an image that has first been smoothed with something approximating a gaussian smoothing filter in order to reduce its sensitivity to noise.Considering the Gaussian function in one dimension, it may be expressed as(6),

$$G(x) = \frac{1}{(\sqrt{2\pi\sigma})} \exp(-\frac{x^2}{2\sigma^2}) \quad (6)$$

Its first and second derivatives can be expressed as (7) (8) respectively,

$$G(x) = \frac{-x}{(\sqrt{2\pi\sigma^2})} \exp(-\frac{x^2}{2\sigma^2}) \quad (7)$$

$$G(x) = \frac{1}{(\sqrt{2\pi\sigma^2})} \exp(-\frac{x^2}{2\sigma^2}[1 - \frac{x^2}{\sigma^2}]) \quad (8)$$

The first derivative of the image convolved with a Gaussian function,

D[Gauss(x,y)*f(x,y)] (9)

is equivalent to the image function convolved with the first derivative of Gaussian,

D[Gauss(x,y)]*f(x,y)) (10)

Therefore, it is possible to consolidate the smoothing and detection stages into a single convolution in one dimension, either convolving with the first derivative of Gaussian and looking for peaks, or with the second derivative and looking for zero crossings[8][11].

The algorithm for detecting edges using the Laplacian of Gaussian filter used is as follows:

- *Apply LOG filter.*
- *Check for zero crossings.*
- *Threshold based on gradient magnitude.*

### C. *Morphological Gradient*

The morphological gradient of a gray scale image can be defined as the difference between intensity values of two neighboring pixels that belong to a given structural elemen[6]t. A classic definition of morphological gradient is given in (11)

$$\nabla(f) = \delta_g(f) - \varepsilon_g(f) \qquad (11)$$

We use D instead of $\nabla(f)$. Applying equation 11 for a 3x3 matrix, we obtain the coefficients $z_i$ with figure 3and the possible direction of edge $D_i$ with equation 12.The edges S can be calculated with equation 13 [7].

$$D1=\sqrt{(z_5 - z_2)^2 + (z_5 - z_8)^2} \qquad (12a)$$

$$D2=\sqrt{(z_5 - z_4)^2 + (z_5 - z_6)^2} \qquad (12b)$$

$$D3=\sqrt{(z_5 - z_1)^2 + (z_5 - z_9)^2} \qquad (12c)$$

$$D4=\sqrt{(z_5 - z_3)^2 + (z_5 - z_7)^2} \qquad (12d)$$

S=D1 + D2 + D3 + D4 (13)

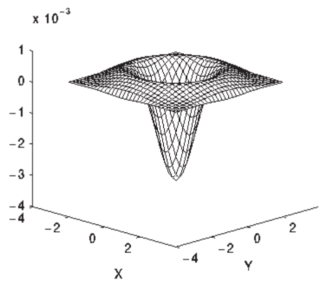



Figure 1: The 2-D Laplacian of Gaussian (LoG) function. The *x* and *y* axes are marked in standard

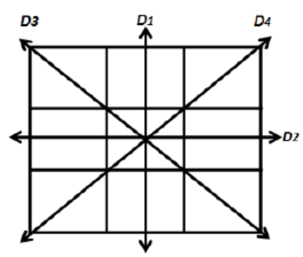


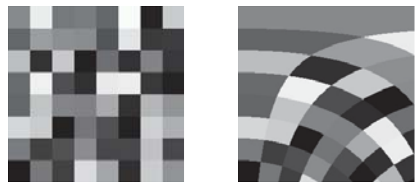

Figure 2: 3x3 matrix indicating the directions Di

| | | |
|---|---|---|
| $z_1$= *f(x-1, y-1)* | $z_2$= *f(x+1,y-1)* | $z_3$= *f(x+1, y-1)* |
| $z_4$= *f(x+1, y)* | $z_5$= *f(x, y)* | $z_6$= *f(x+1, y)* |
| $z_7$= *f(x-1, y+1)* | $z_8$= *f(x, y+1)* | $z_9$= *f(x+, y+1)* |

Figure 3: 3x3 matrix indicating the coefficients Zi.

## III. SIMULATION RESULTS

The simulation results of the edge detectors in MATLABA2010 are shown.This simulation is done using two synthetic images, square and polar, both created in MATLABA2010[6][12]



4(a) 4(b)

Figure 4(a)Square Synthetic Image

4(b)Polar Synthetic Image

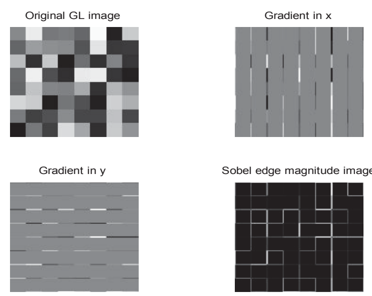



Figure5: Simulation of Sobel Edge Detector using 4(a)

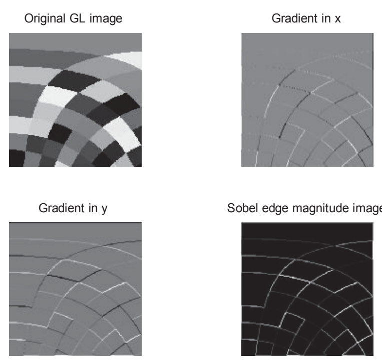



Figure 5 : Simulation of Sobel Edge Detector using 4(b)

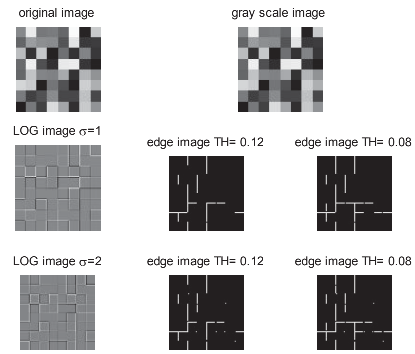



Figure6 Simulation of Log Edge Detector using4(a).

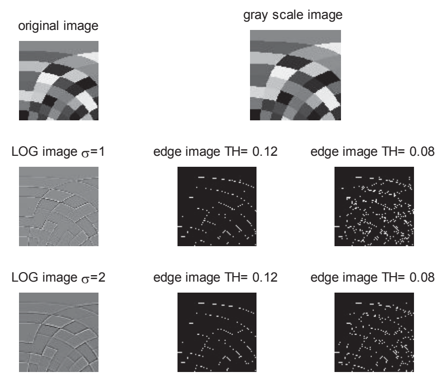



Figure 7Simulation of LoG Edge Detector using4(b).

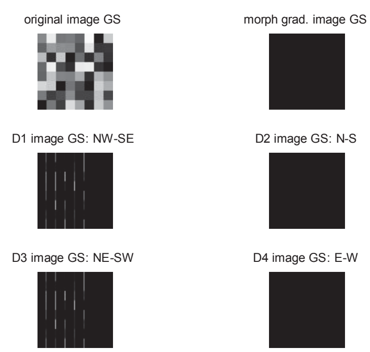



Figure 8Simulation of Morphological Gradient Edge Detector using test image

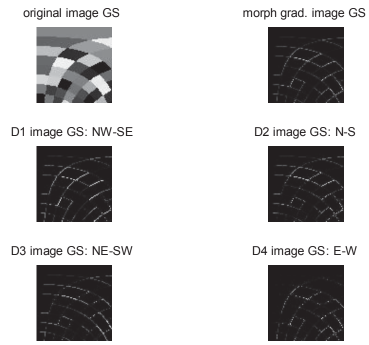



Figure 9Simulation of Morphological Gradient Edge Detector using synthetic image

The Peak Signal to Noise Ratios of these edge detectors with the synthetic image as tabulated as follows:

| Edge Detector Used | Type of Image | PSNR (in dB) | % improvement over Roberts filter (11.9071,10.9996) |
|---|---|---|---|
| Sobel | Square 4(a) | 15.7709 | 24.49 |
| | Polar 4(b) | 13.9139 | 20.94 |
| Laplacian of Gaussian | Square 4(a) | 12.1094 | 1.67 |
| | Polar 4(b) | 11.5846 | 5.04 |
| Morphological Gradient | Square 4(a) | 12.5984 | 5.48 |
| | Polar 4(b) | 12.2434 | `10.15 |

## IV. CONCLUSION

The two popular edge detectors, Sobel and LoG are compared with a modified Morphological Gradient edge detector. The simulation results are shown. The values of PSNR are given which shows that for the given synthetic images, sobel edge detector has the highest PSNR value, followed by Morphological Gradient edge detector. The PSNR values of Morphological Gradient edge detector and Laplacian of Gaussian edge detector are close enough. But, it is to be noted their performance might vary with the image it is tested upon.

## REFERENCES

[1] V. Torre, T. A. Poggio, On Edge Detection, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 8, no. 6. 1986, pp. 147–163

[2] M. Setayesh, M. Zhang, and M. Johnston, "Effects of static and dynamic topologies in Particle Swarm Optimisation for edge detection in noisy images," in 2012 IEEE Congress on Evolutionary Computation, 2012, pp. 1–8.

[3] O. R. Vincent, O. Folorunso, A Descriptive Algorithm for Sobel Image Edge Detection, Proceedings of Informing Science & IT Education Conference (InSITE) 2009

[4] Wenshuo Gao, Lei Yang, Xiaoguang Zhang, Huizhong Liu "An Improved Sobel Edge Detection" 978-1-4244-5540-9/10/$26.00 ©2010 IEEE

[5] J. M. S. Prewitt, "Object enhancement and extraction"," B.S. Lipkin, A. Rosenfeld (Eds.), Picture Analysis and Psychopictorics, Academic Press, New York, NY, pp. 75–149, 1970

[6] Priyanka Thakur,.ArshiaAzam, "Edge Detection Through Integrated Morphological Gradient and Fuzzy Logic Approach", Internation Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 5, May 2015, pp. 1613-1616.

[7] http://homepages.inf.ed.ac.uk/rbf/HIPR2/log.htm
[8] R. C. Gonzalez, R. E. Woods and S. L. Eddins, Digital Image Processing using Matlab, Pearson Prentice Hall, 2004.
[9] http://www.ijera.com/papers/Vol3_issue3/BY33458461.pdf
[10] http://unaab.edu.ng/publications-abstract/A%20Descriptive%20Algorithm%20for%20Sobel%20Image%20Edge%20Detection.PDF
[11] "Digital Image Processing", R.C. Gonzalez and R.E. Woods, 3rdEdition, Prentice-Hall, 2008.
[12] http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/MARBLE/low/edges/canny.htm
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