Experimental Analysis of Impact of Noise on Various Edge Detection Techniques

Ranjeet Kumar Singh, and Dilip Kumar Shaw

Abstract— **Edge detection is a technique that can be used in various image securities concepts like image watermarking and image authentication system. It is a way to authenticate the objects i.e., videos, images and texts. It is also used to locate and identifying the sharp discontinuities available in an image. In this paper author describes the effect of noise on different edge detection techniques like Sobel, Robert, Prewitt's operators practically and showing their results. We apply Gaussian, Speckle and Salt & Pepper noise on the images received after applying various operators of edge detection and then compare their PSNR, MSE values with original edged image received by different edge detection techniques and noisy edge image received after applying various type of noises such as Gaussian, Speckle etc. The experimental results are shown using various Tables and Figures.**

Index Terms- **Correlation Coefficient, LSB Watermarking, PSNR, SNR**

I. INTRODUCTION

Edge detection is a technique for locating and identifying the sharp discontinuities available in an image. The term discontinuities can be referred as sudden modifications intensity of pixel which characterizes objects boundaries in a scene or image. Standard methods for detecting edge consist of involving the image with an edge detection operator, and that is constructed to be sensitive for large gradients in the image while returning values zero in uniform regions. Now a day, a large number of edge detection techniques are available, and their operations are designed to be sensitive toward certain types of edges. Edge orientation is one of the variables which can be considered by edge detection operator for edge detection of image. The geometry of an operator is responsible for determining the characteristic direction which is the direction in which it is most sensitive to edges. Operators can be optimized by looking for various edges such as vertical edge, horizontal edge or diagonal edges. In the noisy image, finding the edge is very difficult because both i.e. edge and noise contain high frequency.

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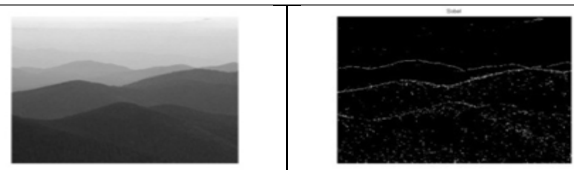
II. EDGE DETECTION TECHNIQUES

A. *Sobel Operator*

The Sobel operator one of the operator which is used to find the edge of image in the field of image processing. Technically, Sobel operator is a discrete differentiation operator, which computes an approximation of the gradient of the image intensity function. The result of the Sobel operator at each point in the image is any relatively gradient vector and the normal to this vector. The Sobel operator is built on convolving the image with a minor, separate, and numeral valued filter in horizontal and vertical direction, due to this it is relatively inexpensive in terms of computations. The figures shown below consist of an original image and its edges image calculated using Sobel operator.



Original image | Edge image of original image

Fig1 Original Image and Edge Calculated by Sobel Operator

B. *Robert's Cross Operator*

The Roberts Cross operator performs a simple and quick processing to compute 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point [1].

+1	0
0	-1

G_x

0	+1
-1	0

G_y

Fig 2 Masking used for Robert operator.

This operator contains of a pair of 2×2 convolution kernels which is given in Figure 2. One kernel is basically represents the rotation of other by 90° [2] .This operator is very similar to the Sobel operator. These kernels are designed to respond maximally to edges running at 45° to the pixel grid. Generally, one kernel is responsible to respond for each of the two perpendicular orientations. Kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation i.e. G_x and G_y. These gradient are then combined together to find the absolute or resultant magnitude of orientation of gradients at each point. The absolute gradient magnitude is given by: -

$$|G| = \sqrt{(Gx^2 + Gy^2)}$$

Typically, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy|$$

Above equation is faster in computation. The angle of orientation of the edge give rise to the spatial gradient (relative to the pixel grid orientation) is given by:

$$q = arc\left[\tan\left(\frac{Gy}{Gx}\right)\right] - 3p/4$$

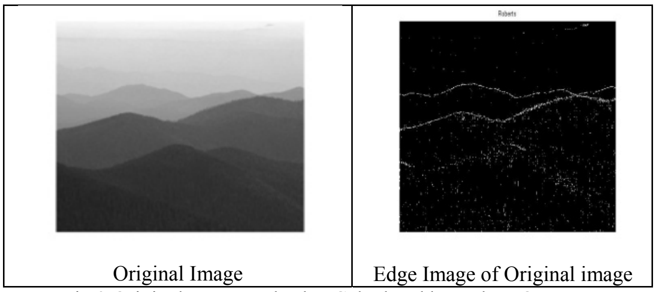


Fig 3 Original Image and Edge Calculated by Robert Operator

C. *Prewitt Operator*

Prewitt operator is one of the edge detection operators which are also similar to the Sobel operator. Generally this operator is used for finding both vertical and horizontal edges in cover images [1].

-1	0	+1
-1	0	+1
-1	0	+1

G_x

+1	+1	+1
0	0	0
-1	-1	-1

G_y

Fig 4 Masking used for the Prewitt Operator

III. IMAGE NOISE

It is defined as variation in image due to brightness or colour information, which is produced by sensor, circuitry of scanner or digital camera or other electronic equipment's [4]. This variation is called image noise. Image- noise originates also in film gain. Image noise affected image. It is highly affected by product of image capture. There are three types of basic noises exists in images.-

(1) Salt & Pepper noise
(2) Amplifier noise (Gaussian noise)
(3) Speckle noise

A. *Salt & Pepper Noise:*

When the image consists of some bright intensity pixel in dark region and dark intensity pixel in bright region then it is due to Salt & Pepper noise [5]. This noise in an image is also caused by errors during analogy to digital convertor or by errors during transmission of image so called bit errors. Salt & Pepper noise can be eliminating by interpolating around dark/bright pixel or by using dark frame subtraction. The Probability density function for Salt & Pepper noise is defined [6] as

p.d.f. Salt & Pepper = {A for g=a ('pepper'), B for g = b ('salt')}

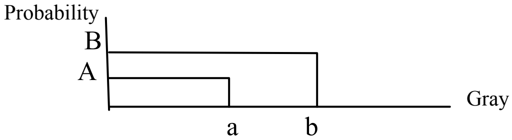


Fig 5 Probability density function for the Salt & Pepper noise

B. *Amplifier Noise (Gaussian Noise)*

This is the noise in image introduced by the variation or variance in signals base on probability distribution or Gaussian distribution. Image sensors generally have constant noise level in dark areas of image. In color cameras where more amplification in blue channel than in green channel or red channel there is more noise in blue comparative to red and green channel.in Gaussian noise intensity of totally pixels of an image changed by small amount.it is frequently not dependent on time, it means it is not planed, randomly changed the value of pixels of an original image.

C. *Speckle Noise*

It is granular noise that inherently exits and it is degrades the quality of active radar and synthetic aperture radar (SAR) image [4]. For example speckle noise is caused by signal from elementary scatter, the gravity-capillary ripples. Speckle noise in SAR is generally more serious and this must be removing as much as possible for smooth and correct working of system. It is create difficulties for image interpretation. Speckle noise in conventional radar is caused due to random fluctuations in the return signal from an object that is smaller than signal image-processing element.

IV. PROPOSED WORK

In this work author shows the comparative analysis and result of various type of noise when involved in image and its edged image. We tried to consider above and its affect at as many as possible variances value. Fig. 6 shows the working structure of experiment.

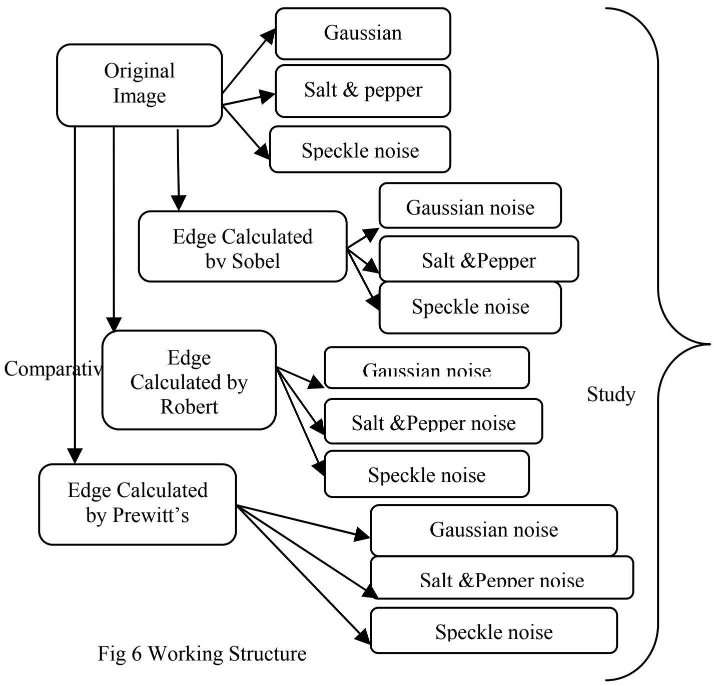


Fig 6 Working Structure

Table I: Edge Detection by various operators of original Image and then by adding various types of noises to original image

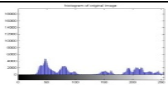
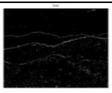
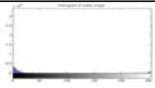
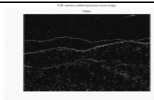
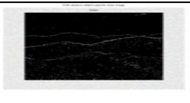
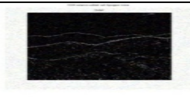
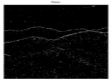
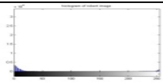
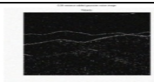
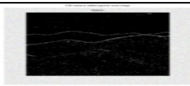
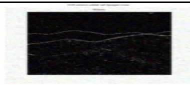
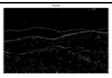
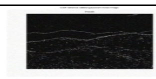
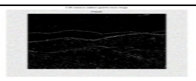
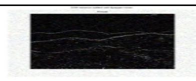
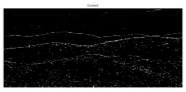
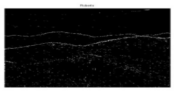
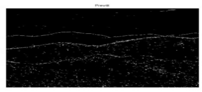
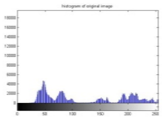
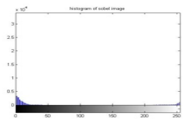
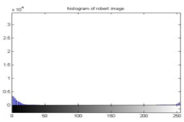
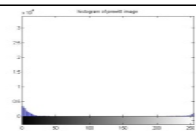
	Image	Histogram	Gaussian noise with variance 0.04	Speckle noise with variance 0.04	Salt & Pepper noise with variance 0.04
Original image					
Sobel					
Robert					
Prewitt					

Table II: PSNR and MSE comparisons of original image to edged images calculated by Sobel, Robert and Prewitt

	Original image	Edge calculation by Sobel edge detection operator	Edge calculation by Robert edge detection operator	Edge calculation by Prewitt edge detection operator
Image				
Histogram				
MSE	-------	12413.35	12327.85	12422.45
PSNR	--------	7.23	7.26	7.22

V. EXPERIMENTAL ANALYSIS

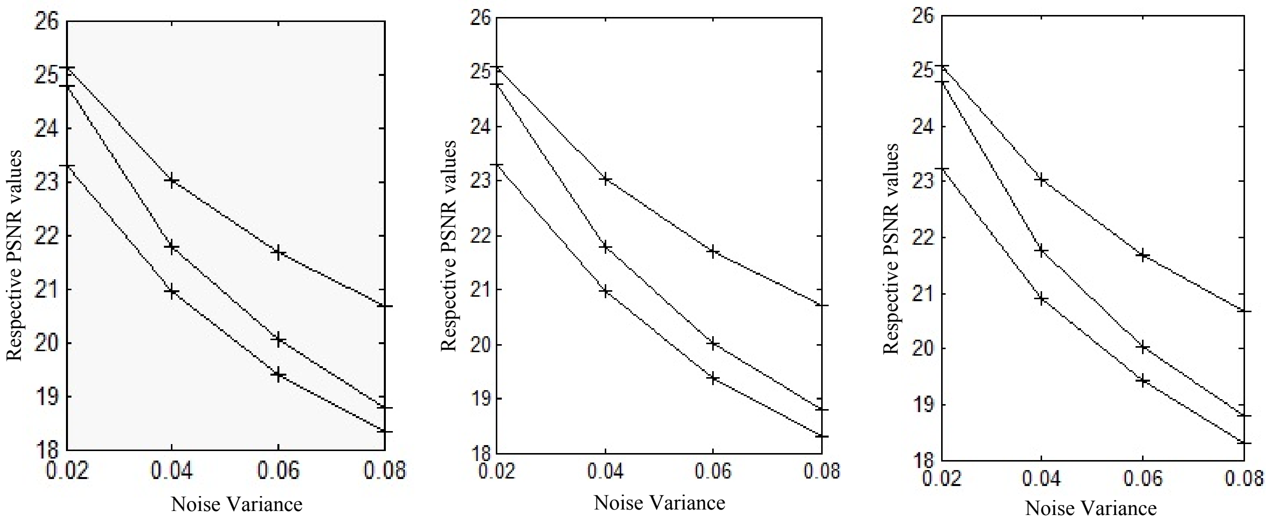
Above Tables i.e. Table 1 and Table 2 show the experimental analysis of this paper. Table 1 contains the images showing the effect of various noises like Salt & Pepper, Gaussian and Speckle noise on original image and its edged images obtained by Sobel, Robert and Prewitt edge detection operators. Table 2 shows the PSNR and MSE comparisons between original image and edged images of original image calculated by Sobel, Robert and Prewitt edge detection technique. In Table 2 we find that the PSNR value for image by Robert edge detection technique is greater in comparison to Sobel and Prewitt edge detection technique. Also the PSNR values of image by Prewitt operator are lowest in comparison to other.

VI. EXPERIMENTAL RESULT

Table 3 shows the comparative analysis of three edge detection technique when different type of noise attacked with different variances. This experiment shows what will be the impact on quality of edge image when the image is noisy or noise attacked on original image with different noise variance. In this experiment author takes three different types of noise such as Gaussian, Salt & Pepper and Speckle noise with variance 0.020, 0.040, 0.060, 0.080. Table.3 represents PSNR value between edge image calculated by Sobel, Robert, Prewitt operators and noisy edge image with different variances. In Table 3 we see the PSNR values between edge image and noise image (variance 0.020) is high when the speckle noise is attacked and less when Salt & Pepper noise is attacked. PSNR comparison between edge image calculated by edge detection operator and noisy image (Gaussian noise attacked) is less than speckle noise attacked but more than Salt & Pepper noise attacked. PSNR values when the speckle noise is attacked is more and Gaussian noise attacked is less, that means Gaussian noise more affected to speckle noise. Fig. 7 shows the impact of different noise techniques on edged images of original image calculated by Sobel, Robert and Prewitt edge detection techniques. The top line shows the effect Speckle noise, middle line shows the effect of Gaussian noise and bottom line shows the effect of Salt & Pepper noise. Fig. 7(a) represents the PSNR comparisons between edged images of original image calculated by Sobel edge detection technique and noisy images (different-different noise with different-different variance, such as Gaussian, Salt & Pepper, Speckle noise). Similarly fig. 7(b) and fig. 7(c) show the PSNR comparisons between edged images of original image calculated by Robert and Prewitt edge detection techniques and noisy images.

Table III: Comparison of PSNR values of edged images of original image using different types of noise

	PSNR of image with Gaussian noise			PSNR of image with Speckle noise			PSNR of image with Salt & Pepper noise		
1 Variance	Sobel	Robert	Prewitt	Sobel	Robert	Prewitt	Sobel	Robert	Prewitt
0.020	**24.79**	24.78	24.79	**25.09**	25.10	25.11	**23.24**	23.30	23.30
0.040	**21.77**	21.78	21.78	**23.05**	23.03	23.02	**20.90**	20.96	20.94
0.060	**20.05**	20.01	20.04	**21.68**	21.69	21`.67	**19.43**	19.38	19.39
0.080	**18.78**	18.80	18.78	**20.67**	20.72	20.68	**18.30**	18.31	18.32



a. Comparison of PSNR using Sobel   b. Comparison of PSNR using Sobel   c. Comparison of PSNR using Sobel

Fig 7 Impact of different noise techniques on edged images of original image

VII. CONCLUSION

This work practically introduced an impact of various noises on images and edge of original image which is calculated by different edge detection techniques. It also shows the impact of Gaussian noise, Salt & Pepper noise and speckle noise on edged image of original image. Finally, this paper presents the comparative study of noise with various variances and its impact on edge of original image calculated by various edge detection operators.

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