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Spatial Domain Edge Detection of Image in Rainy Weather

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Abstract— Edges are the set of curved line segments where brightness level of image changes sharply. It is one of the most important information of an image which can helps to detect object boundary, its relative position within target area and many other useful information. In edge detection process, edges are retrieved from an image by spotting high intensity variations of the pixels. Edge detection of an image minimizes the amount of processed data effectively and discards information that is less important, keeping the important structural properties of an image. This paper presents a different approach to apply Gradient and LoG operator to get more continuous edges than the conventional one using MATLAB. Their results are compared using peak signal to noise ratio (PSNR). Two images in rainy weather are taken by my camera for case study. It can be used in many applications such as in object tracking, in data compression, in image analysis and medical imaging.

Keywords—*Gradient and LoG; Peak signal-to-noise ratio; Intensity level; Edge detection*

I. INTRODUCTION

Digital Image Processing is an expeditiously growing research area in which a digital image is handled by a digital computer to produce some useful information from it. It is one kind of signal processing in which input is a digital image and output may be an image or characteristic related with it [11].

Edges are the essential information of image which can be detected by various edge detection algorithms in spatial domain and frequency domain as well [11]. Edge detection is a fundamental process in image processing and detection results have direct effects on image analysis. Edge detection significantly minimizes the processing data by removing less relevant information from image[1]. Edge detection algorithms have many applications like segmentation, registration, feature extraction, identification of objects during different weather conditions [2] and also in defense and surveillance system. Edges are extracted by taking gradient or further second order derivative of image. These types of processing are done in spatial domain.

A. Gradient Based Edge Detection Operators

In Gradient based methods edges are extracted by taking first order derivative and then going through local maxima and minima in gradient magnitude in the specified direction. Consider an image function f(x, y) the first order derivative of 'f' at coordinates (x, y) is expressed as [10].

$$\nabla f = G[f(x,y)] = \begin{bmatrix} Gx \\ Gy \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

Magnitude of gradient of f denoted as M(x, y):

$$M(x,y) = magnitude(\nabla f) = |G| = \sqrt{Gx^2 + Gy^2}$$

Or by taking absolute values,

$$M(x,y) \approx |Gx| + |Gy|$$

The direction of the gradient is:

$$\theta = tan^{-1}\left(\frac{Gy}{Gx}\right)$$

The gradient of 2D image is given as [10]

$$Gx = f(x+1,y) - f(x,y)$$

And

$$Gy = f(x,y+1) - f(x,y)$$

There are some gradient operators having their horizontal and vertical masks respectively as follows

- Sobel Operator [9]:

$$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \qquad \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

- Prewitt Operator [9]:

$$\begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \qquad \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

- Roberts Operator [9]:

$$\begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} \qquad \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$$

B. LoG operator

In Laplacian based method, edges are found by searching zero crossings in the second order derivative of image [1], [11].

$$LoG(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right] e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Unlike gradient operators LoG operator have only one mask to compute second order derivative of image [10].

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \qquad \begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix} \qquad \begin{bmatrix} -1 & 2 & -1 \\ 2 & -4 & 2 \\ -1 & 2 & -1 \end{bmatrix}$$

LoG operator has fixed characteristic in all direction and it uses guassian smoothing as pre-processing step to suppress noise. LoG operator is less accurate to find orientation of edges [1].

There are many edge detection techniques which provide continuous edges efficiently but they are complex as well. The purpose of this work is to provide continuous and significant edges by using basic edge operators efficiently and that can be used in noisy environment. For this research work we use two images for case study, first one is of my niece and second input image is of a place in Agra.

II. RELATED WORK

As we discussed earlier for detection of edges we have many methods which are thoroughly discussed in [1], [10] and [11] having their different input images.
In [2] describes a new method of edge detection by making use of entropies to calculate local and global threshold. Similarly morphological and quantum approach is used in [3] and [4] respectively to get efficient edge detection technique.
Reference paper [5] and [8] uses center of mass method to increase continuity of edges provided by Sobel operator. Remaining papers describe applications of edge detection in different fields such as in medical imaging [3], [6] and [12], in image segmentation [9] and object detection [7].

III. PROPOSED METHOD

Gradient operators i.e. Sobel, Prewitt and Roberts operator have two different masks horizontal and vertical mask. By using their masks we can find horizontal and vertical edges separately. This feature of operators is used in following procedure of proposed method as follows:

Procedure for Edge Detection:

Input: A colour image A to process.
Output: A image containing Edges of image A.

Begin
1. Convert input image A into grayscale image.
2. Calculate size [r*c] of grayscale image.
3. Filter grayscale image from 3*3 horizontal mask of respective operator and get horizontal edges.
4. Again filter grayscale image from 3*3 vertical mask of same operator and get vertical edges.
5. Evaluate approximate gradient by adding pixel values of horizontal and vertical filtered image.
6. Compare resultant image with input image and calculate Peak signal to noise ratio.

End Procedure.

Flowchart for proposed procedure:

Figure 1. Flowchart for proposed method

This proposed algorithm can be used for LoG operator by taking same mask for horizontal and vertical direction.

IV. EXPERIMENTAL RESULTS

Some Images are taken during rainy weather and processed by conventional approach at first and then same images are operated according to proposed method which produces resultant images containing edges of original image. We get horizontal and vertical edges of image by filtering it from horizontal and vertical masks of different operators which are as follows:

Figure 2: Input test image 1 of my niece

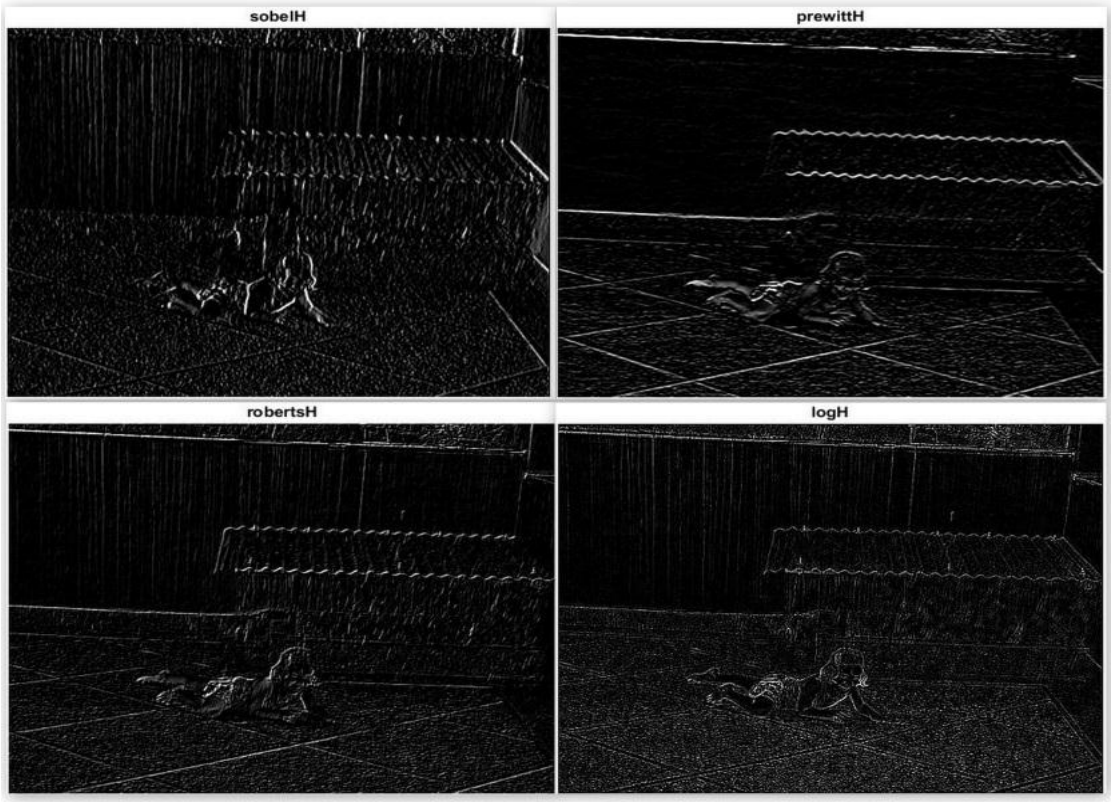

Figure 3: Horizontal edges of input image 1 using different operators

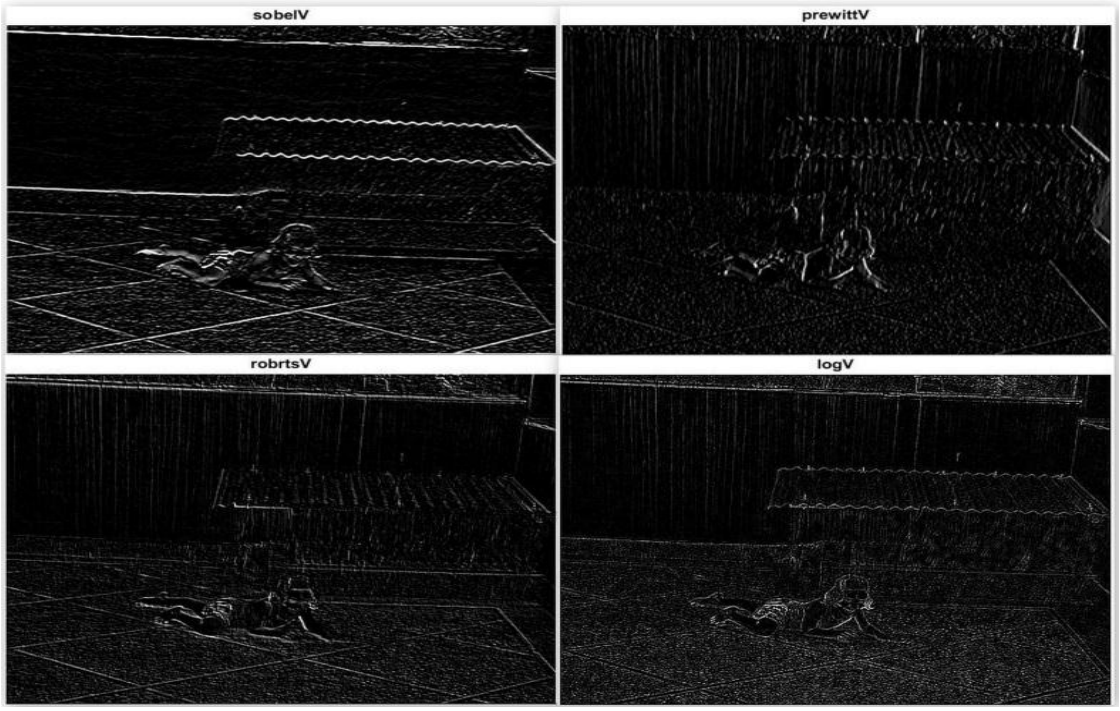

Figure 4: Vertical edges of input image 1 using different operators

Finally, we get output image by taking approximation of gradient through horizontally and vertically filtered images. In following figures input image, result of conventional method and result of proposed method are arranged respectively. Following figures from figure 5 to 8 show output edges obtained through Sobel operator, Prewitt operator, Roberts operator and LoG operator respectively.

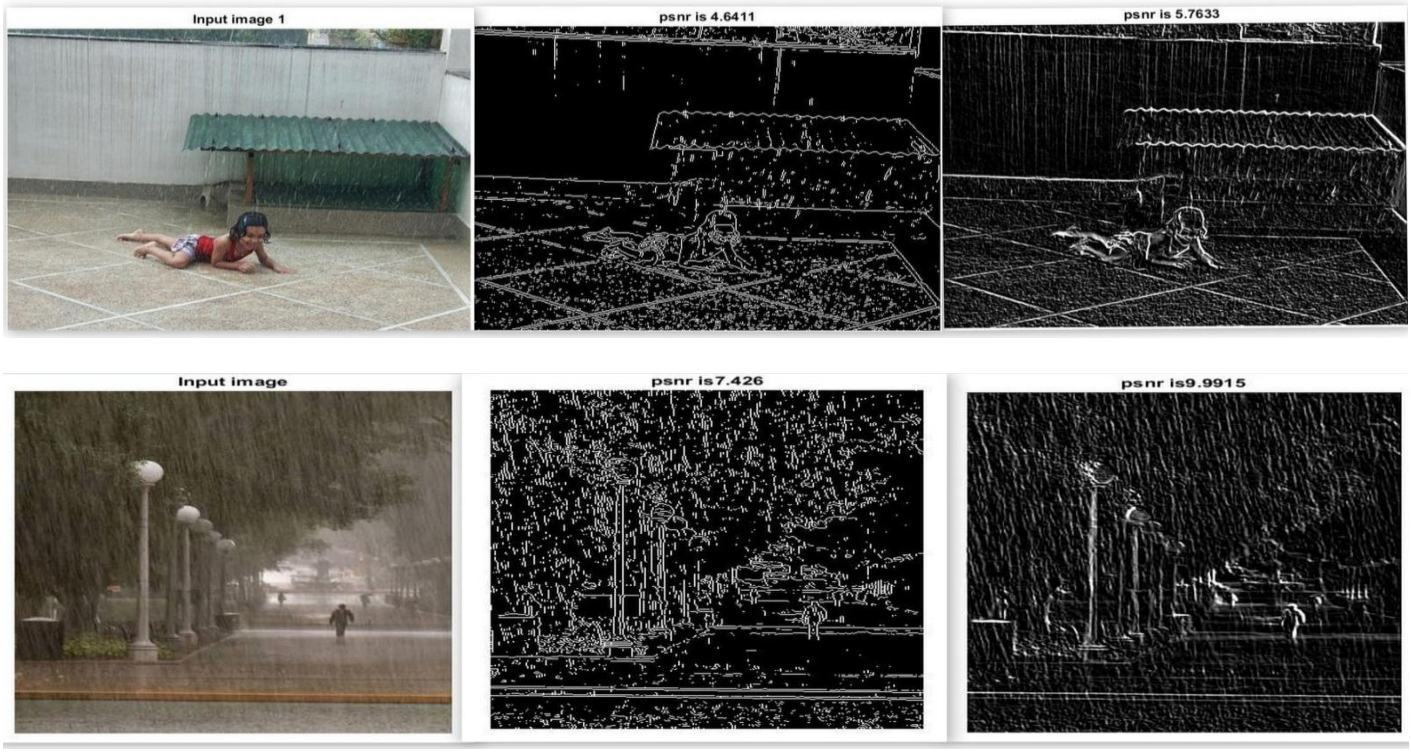

Figure 5: Sobel operator results for Image 1 and Image 2.

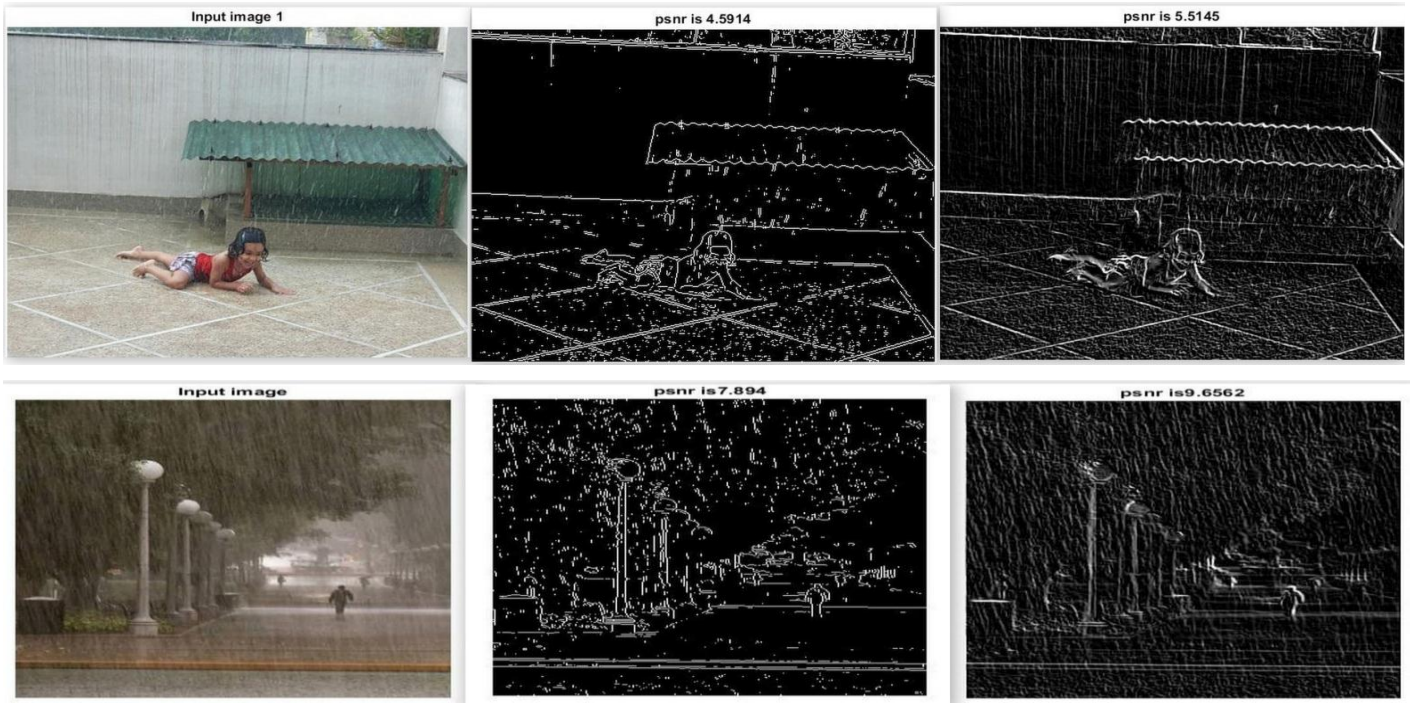

Figure 6: Prewitt operator results for Image 1 and Image 2.

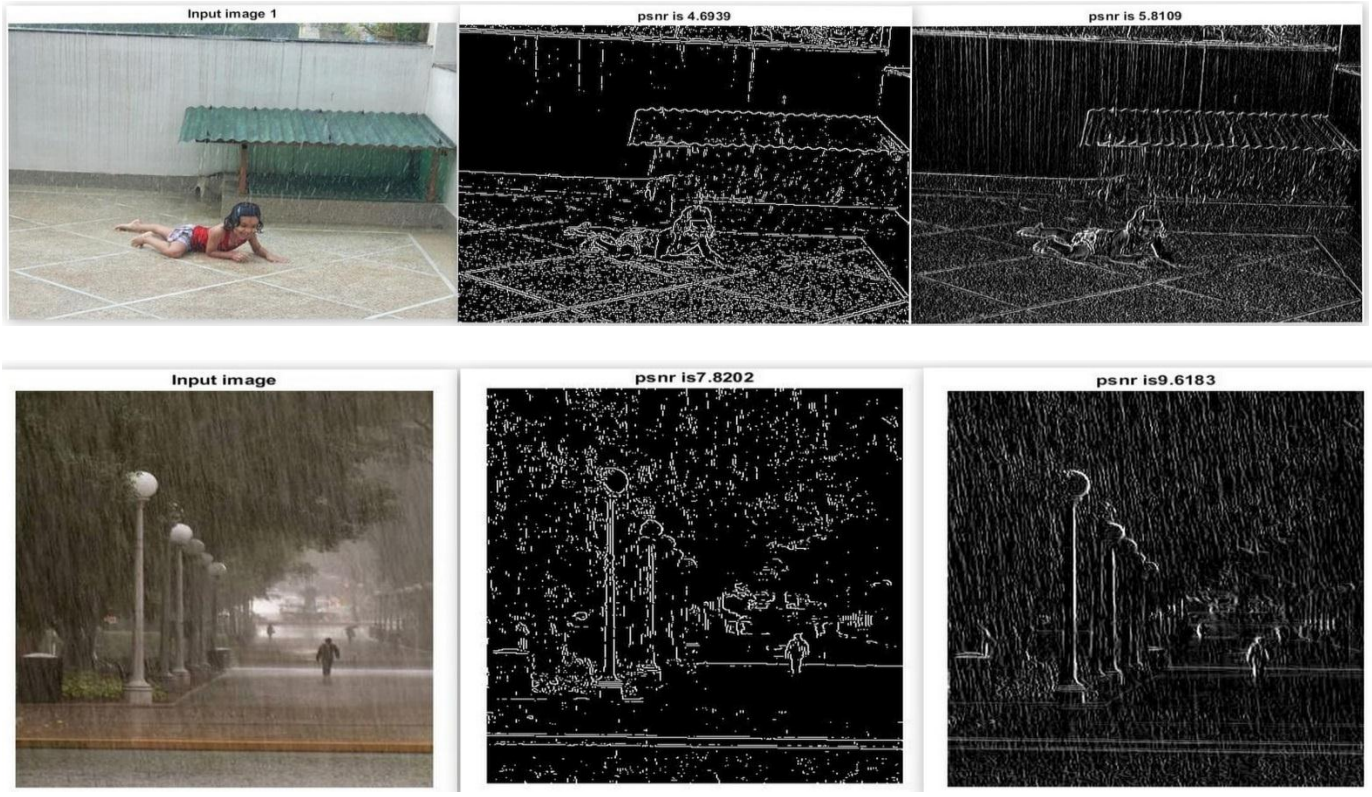

Figure 7: Roberts operated results for Image 1 and Image 2.

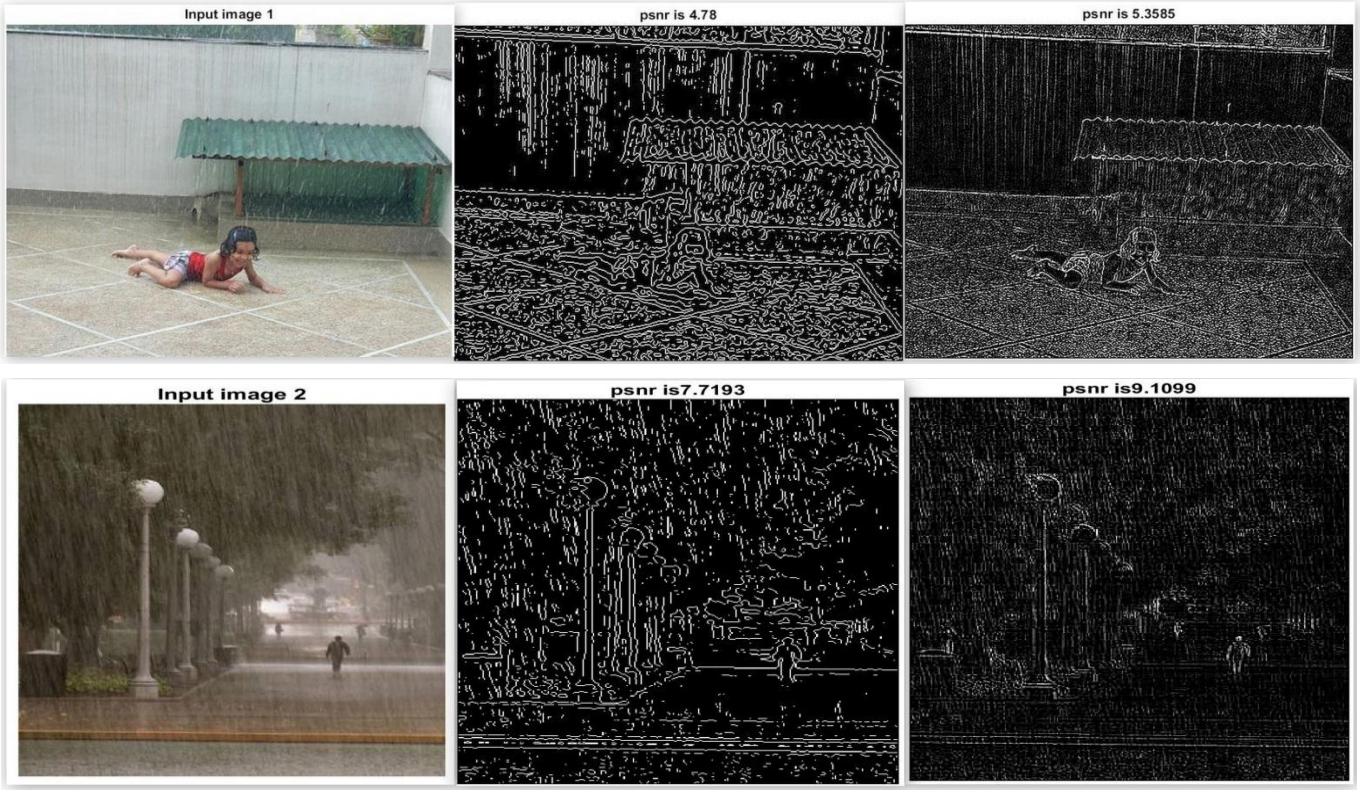

Figure 8: LoG operated results for Image 1 and Image 2.

S.N.	OPERATORS	IMAGE 1		IMAGE 2	
		Conventional method	*Proposed method*	*Conventional method*	*Proposed method*
1.	Roberts	4.6939	5.8109	7.8202	9.6183
2.	Sobel	4.6411	5.7633	7.4260	9.9915
3.	Prewitt	4.5914	5.5145	7.8940	9.6562
4.	LoG	4.7800	5.3585	7.7193	9.1099

TABLE I. PSNR COMPARISON BETWEEN CONVENTIONAL AND PROPOSED METHOD

Experimental results are then analyzed on the basis of PSNR ratio in dB for both images. Results for image 1 and image 2 are tabulated above in Table I. Further these results are presented in Bar graph for Image 1 and Image 2 separately which provides a quick idea to understand the performance of conventional and proposed method in figure 9 and figure 10 respectively.

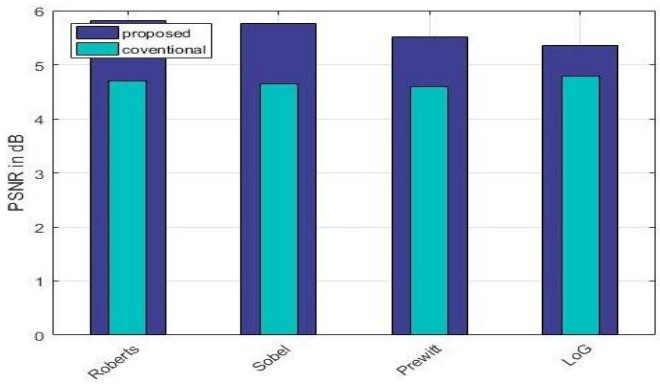

Figure 9: Bar graph for Image 1

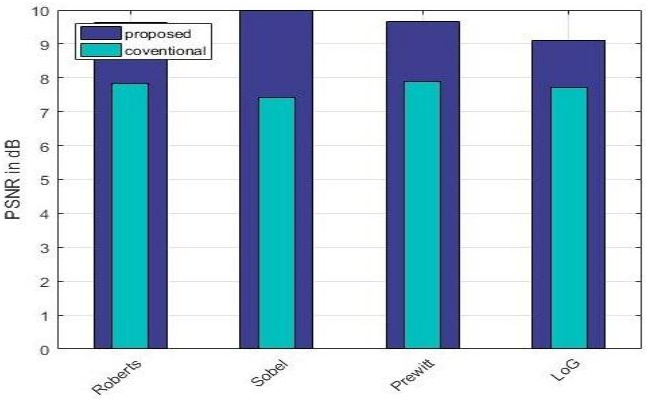

Figure 10: Bar graph of Image 2

Comparison table and Bar graph shows that the conventional approach produces result having 4-7 dB PSNR whereas proposed algorithm provides better results with 5-10 dB PSNR values.

V. CONCLUSION

In this paper, two images are taken and processed by conventional and proposed approach which thereby gives some results containing edges that are analyzed using PSNR ratio. Comparison table and Bar graph concludes that proposed algorithm provides better results with 20% to 25% improvement in PSNR values for all operators. It provides more continuous edges than conventional approach of edge detection. Proposed algorithm also retains original texture of image. This method is very useful to extract edges from image in rainy weather conditions which suggests that it is beneficial to use this method in case of any environmental noise. Better edges helps in precise estimation of information.

The future work might be carrying out to achieve these results in real time. It can be used in various applications i.e. in medical image analysis, for detection of fake currency, in image segmentation and feature extraction, in night vision cameras and in cricket fields. Edge detection has their application in defense and surveillance system also.

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Authors Profile

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