Denoising of Images and Detection of Sharp Edges with Improvement in Classical Edge Detectors

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***Abstract* - Edge detection is an important operation of the image processing to locate the rapid intensity changes in an image. Most of the methods of image edge detection are sensitive to noise. Both, edge and noise information are high-frequency information. Edges contain important information of the image. Image de-noising is a basic and important feature in image processing to remove the noise. Objective of our work is to remove the noise from the noisy image and then detect the edges of that de-noised image with good quality. This paper evaluates the performance of Laplacian of Gaussian edge detector, Prewitt edge detector, Sobel edge detector for detection of edges in a digital image corrupted with Salt & pepper noise. Different levels of noise are studied in order to evaluate the performance of these edge detectors. In this paper, we have used median filtering to mitigate the effect of salt & pepper noise. We present an image de-noising method: Sharpened Edge detection method, to detect the edges of image after the noise filtering is performed. Our method improves the output of these edge detectors and increases the quality of edges. In our method we use adaptive histogram equalization over de-noised image and we get better edge output than the classical edge detectors. Adaptive histogram equalization enhances the contrast of the gray scale image by transforming the values using contrast-limited adaptive histogram equalization. It operates on small regions in the image, called tiles, rather than the entire image.**

***Index Terms* - Edge Detection, Sobel Operator, Laplacian of Gaussian (LoG) operator, Prewitt operator, De-Noising, Salt and Pepper Noise, Median Filter, Adaptive histogram equalization.**

I. INTRODUCTION

Image processing is a type of signal processing, in which the input is an image and the output may be either an image or set of characteristics related to that image. Edge detection is a part of image segmentation techniques which determines the presence of an edge in an image to reduce the amount of data to be processed. Edge representation of an image reduces the amount of data to be processed, yet it retains important information about the shapes of objects in the scene. This edge detection uses in computer vision and other image processing applications to recognize a large number of objects.

An image may be defined as a two dimensional function , f(x,y), where x and y are spatial (plane) coordinates and the amplitude of 'f' at any pair of co-ordinates (x,y) is called the intensity or gray level of the image at that point[5]. The goal of edge detection is to mark the points in a digital image at which the luminous intensity changes sharply. There are several types of noises present in the environment. The aim of image processing is to maintain the quality of any image. Image de-noising is a very important part of image processing. Different filters are used in the process of identifying the image by locating the sharp edges which are discontinuous. These discontinuities bring changes in pixels intensities which define the boundaries of the object. In a particular image, edges determine object boundaries and are useful for segmentation, registration and identification of objects in a scene. Edges are classified into step, line, ramp and roof edges.

Noise

Noise is considered to be any signal that is not part of the area of interest. The principal sources of noise in digital images arise during image acquisition and/or transmission. Poor performance of imaging sensors, unsupportive environmental conditions and interference in the channel used for transmission, are the major factors for arising noise in the image. Images are affected by different types of noises. Departure of ideal signal is generally referred to as noise. Noise can be natural and can be generated artificially. Many image processing packages contain operators to artificially add noise to an image. Deliberately corrupting an image with noise allows us to test the resistance of an image processing operator to noise and assess the performance of various noise filters. Salt & pepper noise is also known as impulse noise. In this type of noise, salt-and-pepper granules randomly distributed over the image. Impulse corruption usually is large compared with the strength of the image signal, impulse noise generally as extreme (pure white or black) values in an image. Am image affected with the salt-and-pepper noise is shown in figure.

Fig. 1: Original image

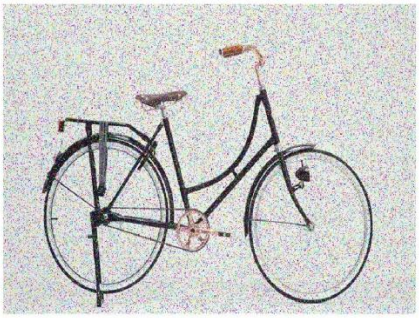


Fig. 2: Noisy image with salt-and-pepper noise

Figure 1 shows the original image taken under consideration for the experiment. **Figure 2** shows the noisy image, which is affected by salt-and-pepper noise.

Median filtering

Median filter, as its name implies, replaces the value of a pixel by the median of the intensity levels in the neighborhood of that pixel: f(x,y)=median{g(s,t)}, where, $(s,t) \in S_{xy}$

The value of the pixel at (x,y) is included in the computation of the median. Median filters are quite popular because, for certain types of random noise, they provide excellent noise-reduction capabilities, with considerably less blurring than linear smoothing filters of similar size. Median filters are particularly effective in the presence of impulse noise, also called salt-and-pepper noise because of its appearance as white and black dots superimposed on an image [5].

Classical edge detectors

Edge detection is a method which is used to identify points in a digital image at which the image brightness changes rapidly. Different types of edge detectors (operators) are available now. In an ideal case, the output of an edge detector applied on an image may lead to a set of connected points that indicate the boundaries of objects in that image. Applying an edge detection algorithm to an image may significantly reduce the amount of data to be processed and may therefore filter out information that may be regarded as less relevant, while preserving the important structural properties of an image. A variety of Edge Detectors are available for detecting the edges in digital images. However, each detector has its own advantages and disadvantages.

The basic idea behind edge detection is to find places in an image where the intensity changes rapidly. Based on this idea, an edge detector may either be based on the technique of locating the places where the first derivative of the intensity is greater in magnitude than a specified threshold or it may be based on the criterion to find places where the second derivative of the intensity has a zero crossing. In this paper we use three edge detectors: Sobel operator, Prewitt operator, Laplacian of Gaussian operator to detect the edges of the image.

Sobel edge detector/operator consists of a pair of 3×3 convolution kernels as shown in Figure. One kernel is simple and other one is rotated by 93°.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Fig. 3: Kernel of sobel edge detector

Prewitt operator is similar to the Sobel operator. It also has 3×3 convolution kernels as shown in Figure and is used for detecting vertical and horizontal edges in image.

−1	−1	−1
0	0	0
1	1	1

−1	0	1
−1	0	1
−1	0	1

Fig. 4: Kernel of prewitt edge detector

Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The operator normally takes a single gray level image as input and produces another gray level image as output. The Laplacian $L(x,y)$ of an image with pixel intensity values $I(x,y)$ is given by:

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

0	1	0
1	−4	1
0	1	0

1	1	1
1	−8	1
1	1	1

−1	2	−1
2	−4	2
−1	2	−1

Fig. 5: Three commonly used discrete approximations to the Laplacian filter

II. RELATED WORK

"Evaluate Combined Sobel-Canny Edge Detector for Image Procssing,", Dr. Luma Salal Hasan 2013: In this paper, presents a brief theory for the sobel kernel and canny edge detector. Then propose an algorithm which combined two detectors, the sobel detector which is widely used in digital image processing and canny edge detector that is another classical techniques. The design consists of three stages. Firstly added salt & pepper noise to the original noise free image file, then use the sobel detector for the file ,then apply canny detector on the results of the second stage to filter the pixel that signed out as an edge in the sobel detection by using Gaussian filter [1].

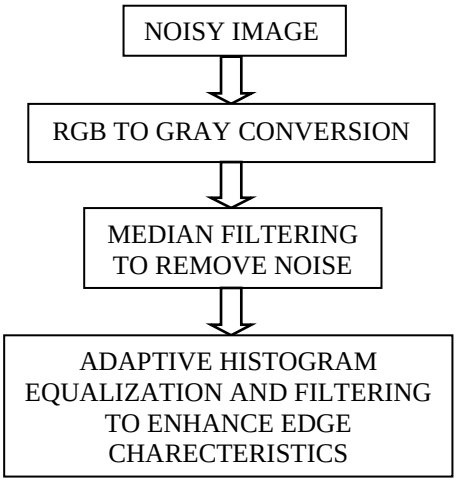
"Image Denoising Using Median Filter with Edge Detection Using Canny Operator",2014, Angalaparameswari Rajasekaran, Senthilkumar. P: In this paper, a novel approach to suppress noise from the image is conducted by applying the median filter. Interquartile range(IQR). The proposed algorithm in this paper focuses on how to effectively detect the noise and efficiently restore the image. Once pixel is detected as noise in previous phase, their new value will be estimated and set in noise reduction phase. The filters are used in the process of identifying the image by locating the sharp edges which are discontinuous. These discontinuities bring changes in pixels intensities which define the boundaries of the object [2].

"Denoising and Edge Detection Using Sobel method" P. Sravya1, T. Rupa devi2, M. Janardhana Rao3, K. Jagadeesh4, T. Prasannakumar5, 2014: This paper presents a method which consists of sobel operator and discrete wavelet de-noising to do edge detection on images which include white Gaussian noise. There were so many methods for the edge detection, sobel is the one of the method, by using this sobel operator or median filtering, salt and pepper noise cannot be removed properly, so firstly they use complex wavelet to remove noise and sobel operator is used to do edge detection on the image [3].

"A Comparative Study of Mixed Noise Removal Techniques", Ajay Kumar Nain, Surbhi Singhania, Shailender Gupta and Bharat Bhushan, 2014: Paragraph comes content here. Paragraph comes content here. Paragraph ** This paper compares mixed noise removal techniques such as: Peer Group averaging (PGA), Vector Median Filter (VMF), Vector Direction Filter (VDF), Fuzzy Peer Group Averaging (FPGA), and Fuzzy Vector Median Filter (FVMF) on the basis of performance metrics such as Peak Signal to Noise Ratio (PSNR), Mean Absolute Error (MAE), Mean Square Error (MSE) and time complexity. The image size and the noise density is varied so as record these performance metrics. From all the above discussion the following points can prove beneficial for the researchers working in the direction of image processing as follows: a.) When the image size is small it is advisable to use PGA but if the image size is large then its better to use FVMF as was also shown from our results. b.) In terms of visual clarity, maximum blurring occurs when FVMF technique is used while PGA gives best visual quality results. c.) As far as computational complexity is concerned best results were obtained for AMF filter followed by Wiener Filter and the least results were obtained for FPGA filter. d.) Moreover, computational complexity is independent of impulse noise density [4].

III. PROPOSED WORK

In this paper, our object is to get sharp edges of an image in the presence of the salt-and-pepper noise. To remove this noise we use median filter. We detect edges of this output with the help of classical edge detectors i.e. LoG operator, sobel operator, prewitt operator, but the edges we get are not as sharp. So, we apply our proposed method. We apply adaptive histogram equalization on the output of median filter and perform filtering. Adaptive histogram equalization enhances the contrast of the gray scale image by transforming the values using contrast-limited adaptive histogram equalization. It operates on small regions in the image, called tiles, rather than the entire image. Each tile's contrast is enhanced. The contrast, especially in homogeneous areas, can be limited to avoid amplifying any noise that might be present in the image. After it we detect their edges with the help of given edge detectors. Thus, we get sharp edges of de-noised image. Proposed algorithm of this paper is shown in figure below.



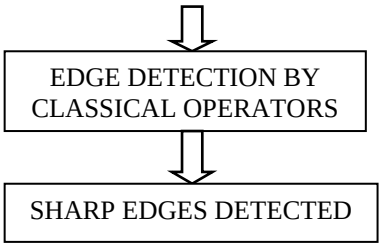


Fig. 6: Proposed algorithm to detect sharp edges

Figure 6 shows the proposed method for De-noising an image and detecting it's sharp edges. This method is very effective and gives very sharp edges of an image. We perform edge detection of an image in presence of salt-and-pepper noise. And we get efficient and sharp edges

IV. RESULTS

This proposed method is performed to detect edges of an image in the presence of the salt-and-pepper noise. During the experiments, we vary the strength of noise from 0.05 to 0.2 (i.e. 5% to 20%). A comparative table of their PSNR and MSE is given below.

Table 1 PSNR and MSE table for different noise levels

Salt and pepper noise (0-1)	Noisy Image		De-noised image	
	PSNR	MSE	PSNR	MSE
0.05	16.82	1.35	26.87	1.33
0.1	13.85	2.68	26.20	1.55
0.15	12.07	4.02	25.38	1.90
0.2	10.80	5.40	24.42	2.34

Table shows that for low level of salt-and-pepper noise peak signal to noise ratio (PSNR) is high and mean square error (MSE) is low. And as the noise level is increasing, PSNR is reducing and MSE is increasing.

Proposed method's edge result with LoG edge detector

This proposed method improves the edge output of the classical edge operators. Results of laplacian of Gaussian edge detector with this proposed method are shown below. In **Figure 7,** first image is the output of LoG operator alone. Second image is the edge of noisy image by the LoG operator again. Third image is the edge of de-noised image, filtered by median filter and its edge detected by LoG operator. Fourth image is the edge of de-noised image by the proposed method of this paper.

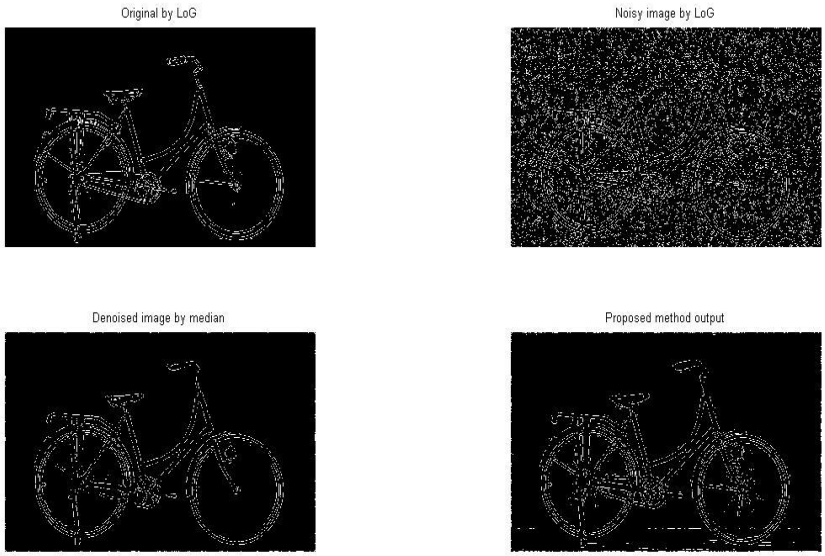


Fig. 7: LoG operator output with proposed method

Proposed method's edge result with sobel operator

Results of Sobel edge detector with this proposed method are shown below. In **Figure 8,** first image is the output of sobel operator alone. Second image is the edge of noisy image by the sobel operator again. Third image is the edge of de-noised image, filtered by median filter and its edge detected by sobel operator. Fourth image is the edge of de-noised image by the proposed method of this paper.

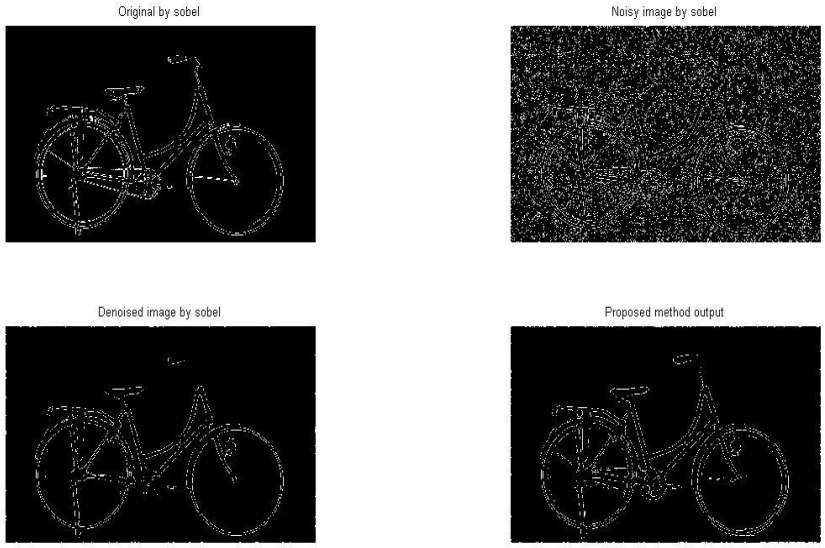


Fig. 8: Sobel operator output with proposed method

Proposed method's edge result with Prewitt operator

Results of prewitt edge detector with this proposed method are shown below. In **Figure 9,** first image is the output of prewitt operator alone. Second image is the edge of noisy image by the prewitt operator again. Third image is the edge of de-noised image, filtered by median filter and its edge detected by prewitt operator. Fourth image is the edge of de-noised image by the proposed method of this paper.

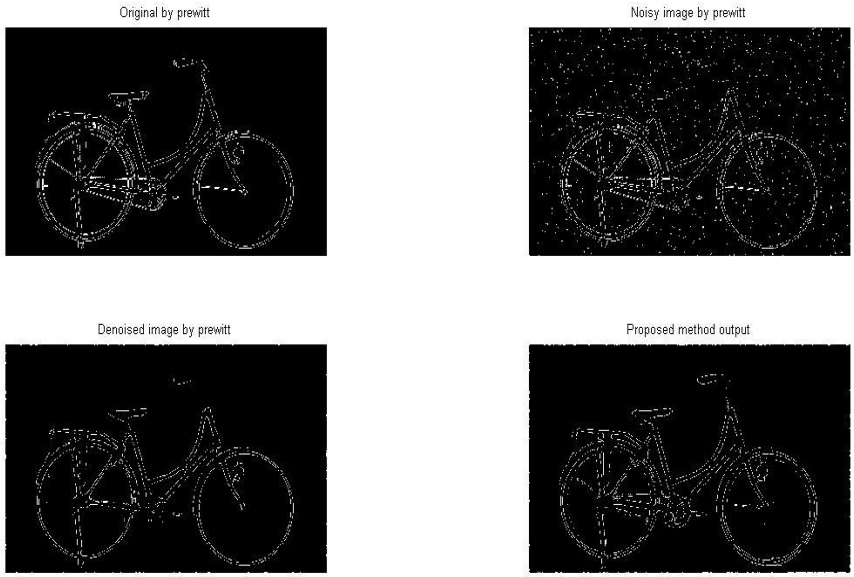


Fig. 9: Prewitt operator output with proposed method

Proposed method's result for a noiseless image

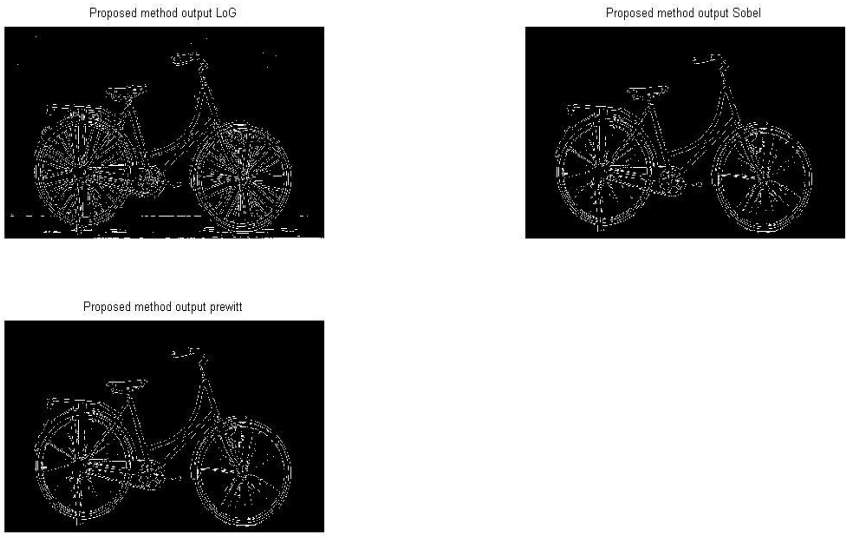


Fig. 10: Proposed method output

In this paper, for noiseless images, this proposed method gives very good efficient edge results. In **Figure 10**, first image is of edge output of proposed method with LoG operator. Second image is of edge output of proposed method with sobel operator. And third image is of edge output of proposed method with prewitt operator. Our edge detection method gives better output than the other classical edge detectors (LoG, sobel, prewitt operator).

V. CONCLUSION

The edge is the simplest and most important property in an image. And the image edge detection plays a very important role in image processing and computer vision. Edge detection is the fundamental implementation in image processing which gives the contour of the object in an image. The ideal result of edge detection can trace the boundary of the object. This paper presents an efficient method for edge detection of an image. This method improves the output of classical edge operators i.e. LoG, sobel, prewitt operator. In this paper we remove the salt-and-pepper noise from the image. After performing filtering with the help of median filter, we used classical edge detectors to detect the edges of image. To improve the quality of these edges, we proposed a new method in which we apply adaptive histogram equalization over the filtered output of the image. Result of this proposed method is very efficient and we get better edges of the image. In future we can apply this method over various kinds of noises available. And further improve the quality of edges.

VI. ACKNOWLEDGMENT

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