Performance and Analysis of Directional Edge Detectors on 3-Planar Images Corrupted with Impulsive Noise

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ABSTRACT

This paper presents the performance of most common edge detectors i.e. Kirsch, Sobel, Prewitt and Robinson in the presence of different percentage levels impulsive noise and also analyze the effect in different planes of a RGB image i.e. Red, Green and Blue planes. For analysis, PSNR is taken as Objective parameter and Subjective analysis of the resultant images. This study is helpful in the domains like Satellite imaging, deep space navigation images and various microscopic images in nuclear science and Bio medical field applications where color information is highly required for better analysis and precise results.

Keywords

Edge Detection, Convolution, Impulsive Noise, Noised Edge Detected Images.

1. INTRODUCTION

According to Andreas Koschan and Mongi Abidi [1] edge detection in gray-level images is a well-established area, while edge detection in color images has not received the same attention. The fundamental difference between color images and gray-level images is that, in a color image, a color vector (which generally consists of three components) is assigned to a pixel, while a scalar gray-level is assigned to a pixel of a gray-level image. Thus, in color image processing, vector-valued image functions are treated instead of scalar image functions (as in gray-level image processing). Color edge operators are able to detect more edges than gray-level edge operators. Thus, additional features can be obtained in color images that may not be detected in gray-level images.

M. EmreCelebi, Hassan A. Kingravi and Y. Alp Aslandogan [8] presented a systematic survey of 48 impulsive noise removal filters using a unified notation. The filters are categorized into families and compared on a large image set in order to ensure an objective appraisal of their effectiveness and efficiency. A fast approximation for the inverse cosine function is introduced to allow for a more even comparison for efficiency. Furthermore, for commonly used distance measures are compared and contrasted. Finally, recommendations selecting filters that meet certain criteria were provided.

Mohamed Roushdy [26] presented Comparative Study of Edge Detection Algorithms Applied on the Grayscale Noisy Image Using Morphological Filter. In this paper, classified and comparative study of edge detection algorithms are presented. Experimental results prove that Boie-Cox, Shen- Castan and Canny operators are better than Laplacian of Gaussian (LOG), while LOG is better than Prewitt and Sobel in case of noisy image. Subjective and objective methods are used to evaluate the different edge operators. The morphological filter is more important as an initial process in the edge detection for noisy image and used opening-closing operation as preprocessing to filter noise. Also, smooth the image by first closing and then dilation to enhance the image before the edge operators affect.

Kyu-Cheol Lee, Kwang-HoonSohn, and Young Huh [27] proposed anew algorithm for effectively removing impulsive noise in digital images. This computationally efficient algorithm first classifies corrupted pixels and then performs median filtering only for them. They introduced new efficiency factors to compare the performance of the noise detection algorithms. Simulation results show that the proposed algorithm performs better than the existing methods in terms of both objective and subjective evaluations.

Raman Maini, J.S.Sohal [21] presented the performance of Prewitt Edge Detector for detection of edges in digital images corrupted with different kinds of noise. Different kinds of noise are studied in order to evaluate the performance of the Prewitt Edge Detector. Further, the various standard test Images are examined to validate our results. It has been observed that the Prewitt Edge

Detector works effectively for the digital images corrupted with Poisson Noise where as its performances reduces sharply for other kinds of noise in digital images. The results of this study are quite promising.

Gurpreet Chahal and Harminder Singh [6] presented a robust statistics based filter to remove salt and pepper noise in digital images. The function of the algorithm is to detect the corrupted pixels first since the impulse noise only affect certain pixels in the image and the remaining pixels are uncorrupted. The corrupted pixels are replaced by an estimated value using the proposed robust statistics based filter. The proposed method perform well in removing low to medium density impulse noise with detail preservation up to a noise density of 70% compared to standard median filter, weighted median filter, recursive weighted median filter, progressive switching median filter, signal dependent rank ordered mean filter, adaptive median filter and recently proposed decision based algorithm.

2. PROPOSED WORK

In this work we will study the performance of most common edge detectors i.e Kirsch, Sobel, Prewitt and Robinson in the presence of impulsive noise (Salt and pepper noise).The study has been extended to analyze the effect in different planes of a RGB image i.e Red, Green and Blue planes. Further, to get more precise results different percentage levels of noise are taken in to consideration.

For analysis, PSNR is taken as Objective parameter and Subjective analysis of the resultant images is also being done. The analysis which is being done in this dissertation is helpful in the domains like Satellite imaging, deep space navigation images and various microscopic images in nuclear science and Bio medical field applications. Further, for some images RGB color space is not required instead we can consider a single plane as that can extract more information. eg. For a particular image Red plane can give more information than other two planes. This saves memory and processing, be done at higher speeds in real time applications.

3. METHODOLOGIES

There are various masks which can be used for Compass Edge Detection. The most common ones are shown in Figure 3.1

0˚

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

45˚

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

-3	-3	5
-3	0	5
-3	-3	5

-3	5	5
-3	0	5
-3	-3	-3

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

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

Fig 3.1 Examples of most common compass edge detecting masks, each example showing two masks out of the set of eight.

For every template, the set of all eight masks is obtained by shifting the coefficients of the mask circularly. The result for using different templates is similar; the main difference is the different scale in the magnitude image. The advantage of Sobel and Robinson masks is that only *4* out of the *8* magnitude values must be calculated. Since each pair of masks rotated about *180°* opposite is symmetric, each of the remaining four values can be generated by inverting the result of the opposite mask [21].

4. RESULT ANALYSES

There are two methods to evaluate the performance of edge detectors, subjective analysis and objective analysis. Subjective analysis methods borrowed from the field of psychology and use human judgment to evaluate the performance of edge detectors. More precisely, these methods involve presenting a series of edge images to several individuals and asking them to assign scores on a given scale. Even these methods seems easy to be put into practice, they have some drawbacks. The number of characteristics a human eye can distinguish is limited. For example, the eye can not differentiate between two colored images that are slightly different. As well, the judgment depends on the individual experience and attachment to the method, as well as on the image type (i.e., density of objects).

4.1 Subjective Analysis

For the above analysis, subjective measure is an impairment test where the test subject scores the images in terms of the effect of noise on connectivity of the edges detected and their number as well. There are two subjective analyses. Subjective analysis is done on the images corrupted with different % of noise. The Subjective fidelity scoring scales are

- 1-Connectivity
- 2-Connectivity with annoyance
- 3-Discontinuity
- 4-Discontinuity with annoyance
- 5-Not usable

This is done on the 512 X 512 Leena and baboon image in all the three planes with the application of following edge detection algorithms: Kirsch, Sobel, Prewitt, and Robinson in both 1-direction and 8-directions with different corruption levels (Impulsive noise). We have obtained the results with the three planar images corrupted with 20%, 40%, 60% and 90%. Results for some of Baboon image are shown below:

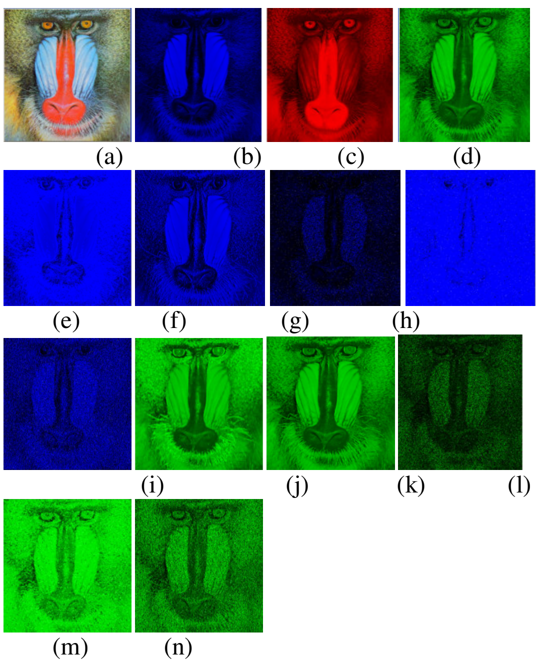

Fig 4.1:(a)Original Baboon image (b) Blue plane (c) Red plane (d) Green plane (e) Kirsch in 8-directions on blue plane (f) Kirsch in 1-direction on blue plane (g) Impulsive noised blue planar image (90%) (h) Kirsch in 8-directions on noised blue plane (i) Kirsch in 1-direction on noised blue plane (j) Prewitt in 8-directions on green plane (k) Prewitt in 1-direction on green plane (l) Impulsive noised green planar image (90%) (m) Prewitt in 8-directions on noised green image (n) Prewitt in 1-direction on noised green image.

Table 4.1:1-Direction Sobel of Baboon image

SUBJECTS	IMPULSIVE NOISE	Sobel
Subject1	20%(Blue)	1
	40%	4
	60%	4
	90%	5
	20%(Green)	3
	40%	4
	60%	4
	90%	5
	20%(Red)	3
	40%	4
	60%	5
	90%	5
Subject2	20%(Blue)	3
	40%	4
	60%	4
	90%	4
	20%(Green)	3
	40%	3
	60%	4
	90%	5
	20%(Red)	3
	40%	4
	60%	4
	90%	5
Subject3	20%(Blue)	3
	40%	4
	60%	4
	90%	4
	20%(Green)	3
	40%	3
	60%	4
	90%	5
	20%(Red)	3
	40%	4
	60%	5
	90%	5

Table 4.2: 8-Directions Sobel of Baboon image

SUBJECTS	IMPULSIVE NOISE	Sobel
Subject1	20%(Blue)	1
	40%	2
	60%	2
	90%	2
	20%(Green)	1
	40%	2
	60%	4
	90%	4
	20%(Red)	1
	40%	4
	60%	4
	90%	4
Subject2	20%(Blue)	1
	40%	2
	60%	2
	90%	2
	20%(Green)	1
	40%	2
	60%	4
	90%	4
	20%(Red)	1
	40%	2
	60%	4
	90%	4
Subject3	20%(Blue)	2
	40%	2
	60%	2
	90%	2
	20%(Green)	2
	40%	4
	60%	4
	90%	4
	20%(Red)	1
	40%	2
	60%	4
	90%	4

Table 4.3: 1-Direction Prewitt of Baboon image

SUBJECTS	IMPULSIVE NOISE	Prewitt
Subject1	20%(Blue)	1
	40%	2
	60%	4
	90%	4
	20%(Green)	1
	40%	1
	60%	4
	90%	5
	20%(Red)	3
	40%	4
	60%	4
	90%	5
Subject2	20%(Blue)	1
	40%	2
	60%	4
	90%	4
	20%(Green)	2
	40%	2
	60%	4
	90%	4
	20%(Red)	3
	40%	4
	60%	5
	90%	5
Subject3	20%(Blue)	2
	40%	2
	60%	4
	90%	4
	20%(Green)	1
	40%	1
	60%	4
	90%	5
	20%(Red)	3
	40%	4
	60%	5
	90%	5

Table 4.4: 8-Directions Prewitt of Baboon image

SUBJECTS	IMPULSIVE NOISE	Prewitt
Subject1	20%(Blue)	1
	40%	1
	60%	2
	90%	2
	20%(Green)	1
	40%	1
	60%	2
	90%	2
	20%(Red)	2
	40%	2
	60%	2
	90%	4
Subject2	20%(Blue)	1
	40%	2
	60%	2
	90%	2
	20%(Green)	1
	40%	2
	60%	2
	90%	2
	20%(Red)	2
	40%	2
	60%	4
	90%	4
Subject3	20%(Blue)	1
	40%	1
	60%	2
	90%	2
	20%(Green)	1
	40%	1
	60%	2
	90%	2
	20%(Red)	2
	40%	2
	60%	2
	90%	2

Table 4.5: 1-Direction Kirsch of Baboon image

SUBJECTS	IMPULSIVE NOISE	Kirsch
Subject1	20%(Blue)	1
	40%	2
	60%	4
	90%	4
	20%(Green)	2
	40%	2
	60%	4
	90%	5
	20%(Red)	1
	40%	4
	60%	4
	90%	4
Subject2	20%(Blue)	1
	40%	2
	60%	4
	90%	4
	20%(Green)	1
	40%	2
	60%	4
	90%	5
	20%(Red)	3
	40%	2
	60%	4
	90%	4
Subject3	20%(Blue)	2
	40%	2
	60%	5
	90%	5
	20%(Green)	2
	40%	4
	60%	4
	90%	4
	20%(Red)	1
	40%	2
	60%	4
	90%	5

Table 4.6: 8-Directions Kirsch of Baboon image

SUBJECTS	IMPULSIVE NOISE	Kirsch
Subject1	20%(Blue)	3
	40%	4
	60%	4
	90%	4
	20%(Green)	4
	40%	4
	60%	4
	90%	5
	20%(Red)	3
	40%	4
	60%	4
	90%	4
Subject2	20%(Blue)	3
	40%	4
	60%	4
	90%	5
	20%(Green)	4
	40%	5
	60%	5
	90%	5
	20%(Red)	3
	40%	4
	60%	4
	90%	4
Subject3	20%(Blue)	3
	40%	4
	60%	4
	90%	4
	20%(Green)	4
	40%	5
	60%	5
	90%	5
	20%(Red)	3
	40%	4
	60%	5
	90%	5

Table 4.7:1-Direction Robinson of Baboon image

SUBJECTS	IMPULSIVE NOISE	Robinson
Subject1	20%(Blue)	1
	40%	2
	60%	4
	90%	5
	20%(Green)	3
	40%	4
	60%	4
	90%	4
	20%(Red)	3
	40%	4
	60%	4
	90%	5
Subject2	20%(Blue)	1
	40%	4
	60%	5
	90%	5
	20%(Green)	3
	40%	3
	60%	4
	90%	4
	20%(Red)	3
	40%	4
	60%	5
	90%	5
Subject3	20%(Blue)	3
	40%	4
	60%	5
	90%	5
	20%(Green)	3
	40%	3
	60%	4
	90%	5
	20%(Red)	3
	40%	4
	60%	4
	90%	4

Table 4.8: 8-Directions Robinson of Baboon image

SUBJECTS	IMPULSIVE NOISE	Robinson
Subject1	20%(Blue)	1
	40%	2
	60%	2
	90%	2
	20%(Green)	2
	40%	2
	60%	4
	90%	4
	20%(Red)	1
	40%	4
	60%	4
	90%	4
Subject2	20%(Blue)	2
	40%	2
	60%	2
	90%	2
	20%(Green)	2
	40%	4
	60%	4
	90%	4
	20%(Red)	1
	40%	2
	60%	4
	90%	4
Subject3	20%(Blue)	2
	40%	2
	60%	2
	90%	2
	20%(Green)	2
	40%	4
	60%	4
	90%	4
	20%(Red)	1
	40%	2
	60%	4
	90%	4

4.2 Objective Analysis

This is done on the 3-planar images corrupted with different % of impulsive noise. Objective methods use to measure the performance of edge detectors using peak signal to noise ratio and mean square error between the edge detected images and original images. These objective methods borrowed from digital signal processing and information theory and provide us with equations that can be used to measure the amount of error in a processed image by the comparison to known image. The Peak Signal to Noise Ratio (PSNR) [40] is calculated as follows:

$$PSNR = 10\log_{10}\{255^2/MSE\}$$

$$MSE = 1/MN\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y) - I'(x,y)]^2$$

where M and N are the total number of pixels in the horizontal and the vertical dimensions of the image, I and I' denote the original and noised image, respectively while MSE denote Mean Square Error. PSNR readings have been taken for edge detectors in 1-direction and 8-directions for all the three planes with impulsive noise corruption of 20%, 40%, 60% and 90%.

- **For Baboon image**

Table 4.9: PSNR values of Sobel in 1-direction

Noise	20%	40%	60%	90%
Red	8.95	7.70	7.09	6.52
Blue	8.03	7.01	6.54	6.08
Green	8.83	7.61	7.06	6.46

Table 4.10: PSNR values of Sobel in 8-directions

Noise	20%	40%	60%	90%
Red	10.62	9.76	9.47	9.26
Blue	10.96	9.82	9.52	9.26
Green	10.30	9.36	9.09	8.88

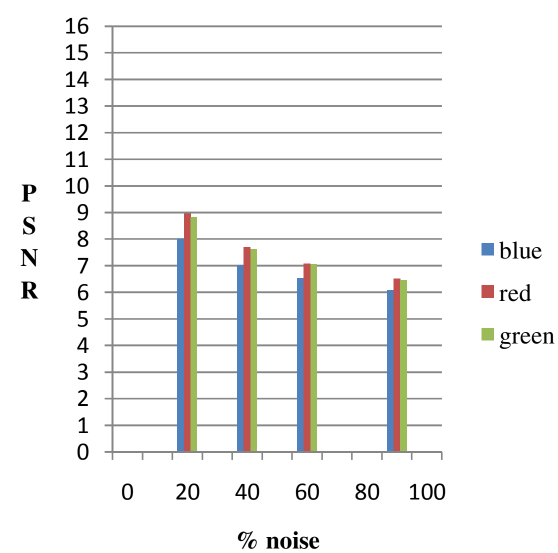

Fig 4.2: PSNR Plot of Sobel (1-direction) for Baboon image corrupted with different noise density.

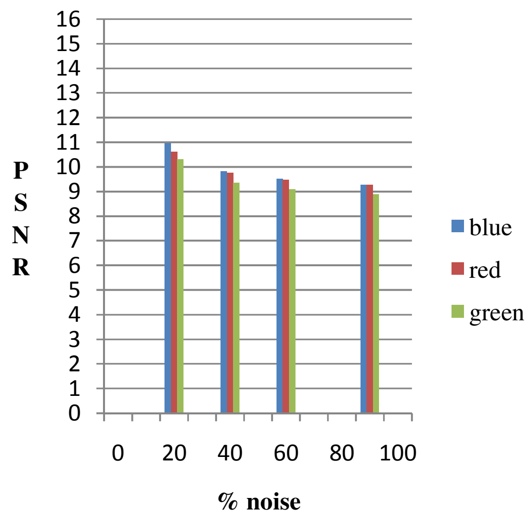

Fig 4.3: PSNR Plot of Sobel (8-directions) for Baboon image corrupted with different noise density.

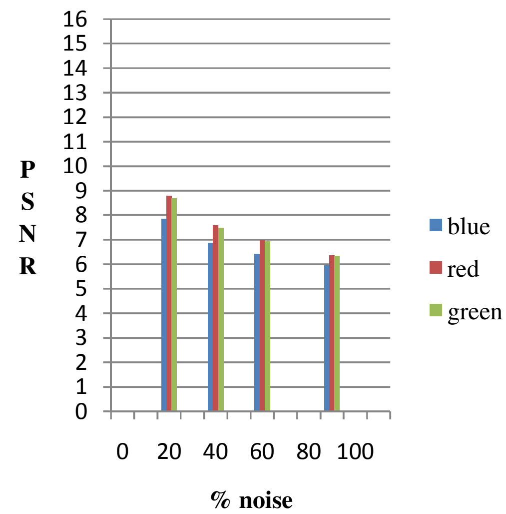

Fig 4.4: PSNR Plot of Prewitt (1-direction) for Baboon image corrupted with different noise density.

Table 4.11: PSNR values of Prewitt in 1-direction

Noise	20%	40%	60%	90%
Red	8.79	7.58	6.97	6.35
Blue	7.85	6.88	6.41	5.95
Green	8.69	7.47	6.92	6.33

Table 4.12: PSNR values of Prewitt in 8-directions

Noise	20%	40%	60%	90%
Red	12.72	11.24	10.73	10.55
Blue	13.22	11.52	11.01	10.73
Green	12.58	10.97	10.47	10.27

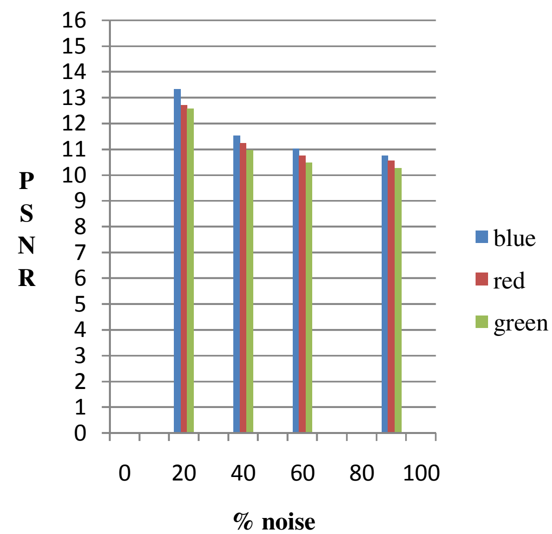

Fig 4.5: PSNR Plot of Prewitt (8-direction) for Baboon image corrupted with different noise density.

Table 4.13: PSNR values of Kirsch in 1-direction

Noise	20%	40%	60%	90%
Red	9.18	7.92	7.30	6.78
Blue	8.31	7.24	6.75	6.31
Green	9.00	7.79	7.19	6.64

Table 4.14: PSNR values of Kirsch in 8-directions

Noise	20%	40%	60%	90%
Red	14.91	14.18	13.94	13.15
Blue	14.20	13.39	13.10	12.30
Green	13.23	12.48	12.28	11.74

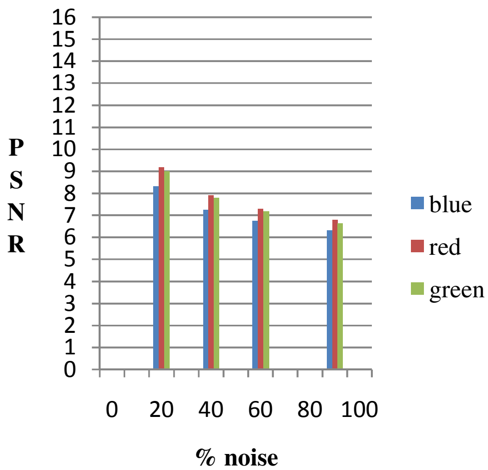

Fig 4.6: PSNR Plot of Kirsch (1-direction) for Baboon image corrupted with different noise density.

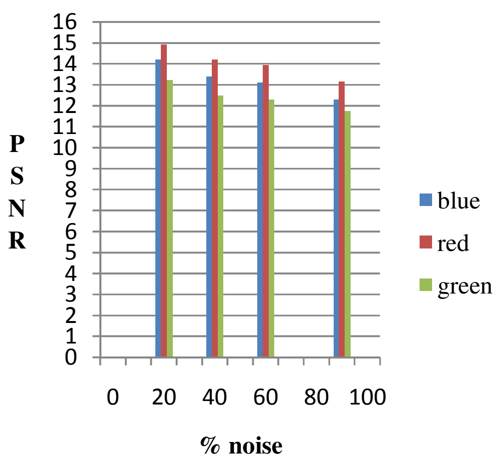

Fig 4.7: PSNR Plot of Kirsch (8-direction) for Baboon image corrupted with different noise density.

Table 4.15: PSNR values of Robinson in 1-direcion

Noise	20%	40%	60%	90%
Red	9.88	8.63	7.97	7.27
Blue	8.58	7.62	7.12	6.60
Green	9.64	8.46	7.84	7.15

Table 4.16: PSNR values of Robinson in 8-directions

Noise	20%	40%	60%	90%
Red	12.29	10.84	10.34	10.13
Blue	12.20	10.56	10.06	9.85
Green	11.87	10.38	9.87	9.68

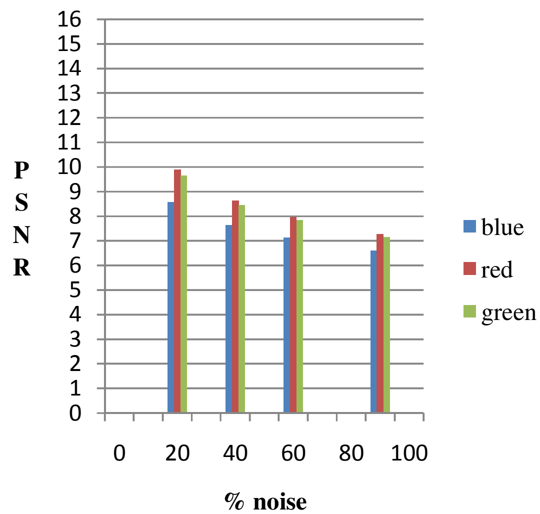

Fig 4.8: PSNR Plot of Robinson (1-direction) for Baboon image corrupted with different noise density.

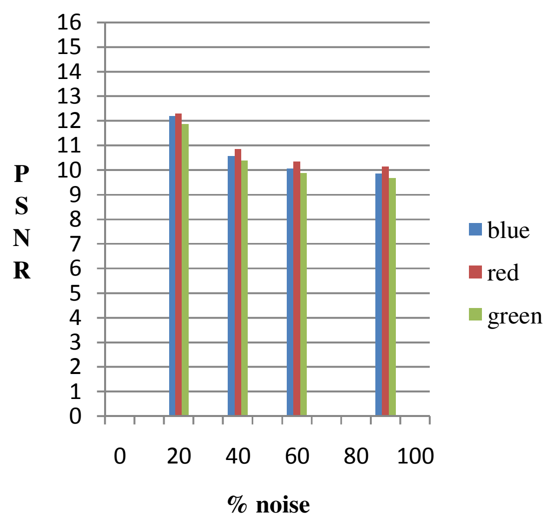

Fig 4.9: PSNR Plot of Robinson (8-direction) for Baboon image corrupted with different noise density.

5. CONCLUSIONS

Pattern of graph in Red, Green, Blue planes for the two images Leena and Baboon respectively is not same as per our prediction. Irrespective of the operator chosen (in both 1 and 8 directional) and the planes (Red, Green, Blue), with the increase in percentage of impulsive noise decreasing trend in PSNR is observed. In comparison between 1-directional and 8-directional operator performance of 8-directional operators is better as drop in PSNR with respect to noise is less. In case of 1-directional operators there is steep variation in all the 3-planes while in case of 8-directional operators there is less variation or almost constant PSNR after 40%.Further if we consider 8-directional operators in presence of impulsive noise 8-directional Kirsch operator works better for Leena image and 8-directional Sobel operator works better for Baboon image.

REFERENCES

[1] Djemel Ziou and Salvatore Tabbone, "Edge Detection Techniques – Overview" http://faculty.cs.tamu.edu/dzsong/teaching/fall2005/cpsc689/slides/Presentation2Edge Detection.pdf
[2] Lianquiang Niu, Wenjuli (2006), "Color Edge Detection on Direction Information Measure", In Proceedings of the sixth world congress on Intelligent Control and Automation
[3] Fabrizio Russo, Member, IEEE, and Annarita Lazzari (2005), Member, IEEE, "Color Edge Detection in Presence of Gaussian Noise using Nonlinear Pre filtering", IEEE Transactions on instrumentation and measurement, Vol. 54, No. 1
[4] Andreas Koschan and Mongi Abidi (2005), "Detection and Classification of edges in Color Images", IEEE, Signal Processing Magazine
[5] Jiang Gangyj, Zheng Yi and Chen Huifang (1996), "Robust Color Edge Detection Using Color Scale Morphology", IEEE Tencon - Digital Signal Processing Applications
[6] Raman Maini and Dr. Himanshu Aggarwal (2009), "Study and Comparison of Various Image Edge Detection Techniques", International Journal of Image Processing (IJIP), Vol. 3: Issue (1)
[7] Gurpreet Chahal and Harminder Singh (2010), "Robust Statistics based Filter to Remove Salt and Pepper Noise in Digital Images", International Journal of Information Technology and Knowledge Management, Vol. 2, No. 2, pp. 601-604
[8] http://en.wikipedia.org/wiki/Impulsive noise (audio)
[9] M. Emre Celebi, Hassan A. Kingravi and Y. Alp Aslandogan (2007), "Nonlinear vector filtering for impulsive noise removal from color images", Journal of Electronic Imaging
[10] Carlo, Alberto De Santis, Danela Lacoviello and Giorgio (2001), "Modeling for Edge Detection Problems in Blurred Noisy images", IEEE Transactions on image processing, Vol.10, pp. 1447-1452
[11] Ehsan Nadernejad, Sara Sharifzadeh (2008), "Edge Detection Techniques: Evaluations and Comparisons", Applied Mathematical Sciences, Vol. 2, no. 31, 1507 – 1520
[12] Lindeberg, Tony (2001), "Edge detection", in Hazewinkel, Michiel, Encyclopedia of Mathematics, Springer, ISBN 978-1-55608-010-4
[13] J koplowitz and V Greco (1994), "On the Edge Location Error for Local Maximum and Zero Crossing Edge Detectors", IEEE Transactions, Vol. 16, pp. 1207-1212
[14] Gonzalez, Rafael, C; Woods, Richard E (2008). Digital Image Processing, 3rd Edition. Pearson Prentice Hall. pp. 577. ISBN 013168728
[15] R C Gonalze and R E Woods and SL Eddins (2004), " Digital Image Processing using MATLAB", Pearson Education Inc.
[16] B Chanda and D Majumdar (2002), "Digital Image Processing and Analysis"
[17] R C Gonzalez and R E Woods (1992), "Digital Image Processing" Addison –Wesley Publications
[18] J Mathews (2002), "An Introduction to Edge Detection: The Sobel Edge Detector" www.generations.org/content/2001/1m01.asp2002
[19] O. R. Vincent, O. Folorunso (2009), "A Descriptive Algorithm for Sobel Image Edge Detection", Proceedings of Informing Science & IT Education Conference (InSITE)
[20] http://en.wikipedia.org/wiki/Sobel
[21] Raman Maini and J S Sohal (2006),"Performance Evaluation Of Prewitt Edge Detector for Noisy Images", GVIP Journal ,Vol. 6 ,issue 3 , pp. 39-45
[22] http://en.wikipedia.org/wiki/Prewitt
[23] http://en.wikipedia.org/wiki/Kirsch
[24] http://en.wikipedia.org/wiki/Robinson
[25] Ehsan Nezhadarya and Rababk.ward (2010), "A Robust Morphological Gradient Estimator and Edge Detector for Color images", IEEE
[26] Mohamed Roushdy (2006), "Comparative Study of Edge Detection Algorithms Applying on the Grayscale Noisy Image Using Morphological Filter", GVIP Journal, Vol. 6, Issue 4
[27] Kyu-Cheol Lee, Kwang-Hoon Sohn, Young Huh (1998), "An efficient approach to impulsive noise filtering"
[28] Slawo Wesolkowski, M. E. Jemigan, and Robert D. Dony (2000), "Comparison of Color Image edge detectors in multiple color spaces", IEEE.