International Journal of Electronics Communication and Computer Engineering
Volume 5, Issue 2, ISSN (Online): 2249–071X, ISSN (Print): 2278–4209

Review and Analysis of Image De-noising Techniques for Impulse Noise Removal

Abhishek Sharma
SIRT Bhopal
Email: abhishektit09@gmail.com

Vijayshri Chaurasia
MANIT Bhopal
Email: vchaurasia@manit.ac.in

***Abstract* – Image noise removal is most important phenomena of image processing. Filtering method is emphasized for all proposed de-noising schemes. In this paper, we have study bout the different algorithms based on non-linear filter to remove the impulse noise from images. Different image noise removal algorithms are analyzed and some parameters are varied in a wide range to study the results of different algorithms. Mathematical analysis show the quality of some de-noising techniques is better than the other methods. Hardware implementations of some techniques are very easy; because less number of calculations required removing the noise.**

***Keywords* – Edge Preservation, Impulse Noise, Median Filter, MSE, PSNR.**

I. Introduction

Digital images are very important source of information but because of the noise generated due to flaws in the system (like imperfection in collection system, transmission medium and imaging system) makes it difficult to study an image for any purposes. Therefore noise filtering is the most important task that one has to do before image processing and hence noise filter plays a very important role in this process. There are two types of filter used for noise filtering they are-

1. Linear filter
2. Non linear filter

Linear [4] [5] filter basically finds the corrupted pixel and replace it with the average /mean of the neighboring uncorrupted pixels as shown below. In linear filter it is assumed that noise is impulse and it takes the value either X_{min} or X_{max} i.e. 255 or 0 thus in this case the corrupted pixel is replaced by mean value of its neighborhood pixels. Linear filter suppresses high density of noise but also unable to preserve the details and leads to blurring of image therefore this filter is not used widely.

Non linear filter is also known as median filter it is the prominently used filter, it removes the noise by replacing every pixel with the median of its neighborhood pixel. Here median is the centre value of the neighborhood pixel i.e. half of the pixel value is above median value and half is below it and since the impulse will take the extreme values the median selected from the neighborhood pixel will give high possibilities of noise free pixel.

The standard non linear [5] filter is used widely because of its high noise elimination factor and the data preserving capability. However, the median filter is related to the filtering window size and due to this relation we have to compromise with either the noise suppression or the data preservation i.e. if the window size is small then the noise suppression is less and data preservation is high whereas if the window is large then the noise suppression is high but the data preservation is not appropriate.

Table I: Filtering window of size 3x3

	Column 1	Column 2	Column 3
Row 1	Z_1	Z_2	Z_3
Row 1	Z_4	Z_5	Z_6
Row 3	Z_7	Z_8	Z_9

So by comparing different types of median filter we will conclude which one should be used for better noise suppression with high data preservation.

II. Impulse Noise Model

This type of noise [3] [5] is major case of image corruption it is independent of image pixel values & random in nature it does not affect all the pixel of image unlike gaussion , but only same no of pixel get effected and rest will be noise free. It shows with black and white dots on image. Impulse noise itself has two types

1. Fixed valued impulse noise (salt & pepper noise)
2. Random valued impulse noise

In salt & pepper noise, the noise changes the value of original pixel with either white spot (gray value-255) or black spot (grey value-0). Its noise model can be represented as

$$Y_n(i,j)=\begin{cases}Y(i,j) & for\text{.........}\ 1-P\\ 0 & for\text{..........}\ P/2\\ 1 & for\text{..........}\ P/2\end{cases}\qquad \text{...........}(5)$$

P= Noise density
Y_n(i, j)= Corrupted Image
Y(i, j)= Original Image

In random value impulse noise, the pixel will be affected by any gray value between 0 to 255 and noise will be randomly distributed over the image. It can be represented as

$$Y_n(i,j)=\begin{cases}Y(i,j) & for\text{....}\ 1-P\\ N(i,j) & for\text{......}\ P\end{cases}\qquad \text{......}(6)$$

N(i, j)= noisy pixels

III. Improved Decision Based Median Filter

This [6] Algorithm is completed basically in two steps: Detection of the corrupted pixels and Substitution of the corrupted pixel with uncorrupted pixel.

The detection of noisy pixel is done the basis of the assumptions that corrupted pixel have the gray value

International Journal of Electronics Communication and Computer Engineering
Volume 5, Issue 2, ISSN (Online): 2249–071X, ISSN (Print): 2278–4209

highly different from their neighboring pixels in the area to be filtered, unlikely the noise free pixels which have smoothly varying gray values. In median filter the difference of the median value of the pixels and the current value of the desired pixel to be check is compared to the threshold value. Now after this comparison a binary flag image is constructed. If its value is 1 the pixel is corrupted and if 0 then the pixel is uncorrupted i.e.

$$b_{i,j} = \begin{cases} 1; & \text{if } \left| m - X_{i,j} \right| \rangle \text{ threshold } ; \\ 0; & \text{otherwise } ; \end{cases} \quad \ldots\ldots(7)$$

The threshold value for this filter is calculated by $(X_{min} + X_{max})/4$ where X_{min} and X_{max} are the minimum and maximum value of the pixel in the window. If the binary flag image took a value 1 then that pixel is replaced by an estimated pixel using median filter for lesser noise density and mean filter for higher noise density. For Example we will consider that the corrupted pixel will take values either X_{max} = 255 or X_{min} = 0. Now these substitutions are different for different number of corrupted pixels.

If the corrupted pixel in the window is ‘n’ and n $\leq$ 4, then a window of size 3X3 is selected and median operation is performed using row sorting and column sorting and diagonal sorting.

If the corrupted pixels ‘n’ are between 5 and 12 in a window than a 5X5 window is selected and then median operation is performed for the substitution of corrupted pixels with the uncorrupted pixels.

If the corrupted pixels ‘n’ are greater than 13 then the median filter fails to work as it leads to blurring of image due to high density noise, so we have to use the average of all the neighbor uncorrupted pixels to replace the corrupted pixel.

IV. Adaptive Switching Median Filter

This process is computationally efficient to remove impulse noise or salt & pepper noise. This is an improvement in Switching median filter (SMF) [1] [3]. This process contains two steps, first one is noise detection, and other one is noise removal. It has a property of adaptively change in the size of filtering window according to the noise density. [10] At the starting of de-noising process, it selects smallest size (3x3) of filtering window. The central pixel X(i,j) of filtering window is compared with minimum and maximum value of that window.

If X(i,j) > minimum and X(i,j) < maximum, then the pixel will left unchanged.

If X(i,j) < minimum and X(i,j) > maximum, then central pixel will considered as noisy and will be replaced by median value of window.

If X(i,j) = minimum and X(i,j) = maximum, then there may be noisy pixel or may have smooth area.

For the further detection, size of filtering window is increased and then again detection process performed. If the central pixel is a part of smooth area, then it will left unchanged, otherwise it replaced with median of that window. The size of filtering window increases up to a limited level.

V. Linear Mean-Median Filter

Figure 1 shows the block diagram of LMMF; consist of noise prediction, detector and pre-filtering section. Two ROM filters are used for reconstruction of noisy pixels.

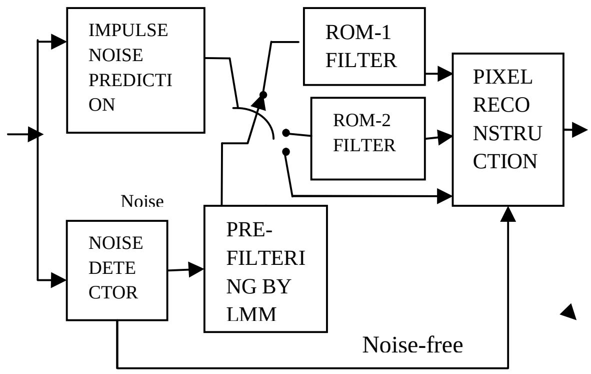


Fig.1. Block Diagram Representation of LMMF

A. Impulse Noise Density Prediction:-

Density Impulse Noise Prediction (p) is amount of noise which mixes on the original image Y(i,j), which is expressed in percent (%).The p data is used to determine the options,. The output option for pre filtering depends upon the value of p, which is expressed as follows:-
For, p < 30%, output is forwarded for Pixel Reconstruction, for 30% < p < 70%, output is forwarded to ROM-2 and for p > 70%, output is forwarded to ROM-1. We predict the density of impulse noise by:

1. We make 2D index matrix $Y_n(i,j)$ with element value 0 or 1. $Y_n(i,j)$ is the corrupted image which is also the reference for $Y_n(i,j)$.
2. Determining the value of index 0 or 1 in each element matrix $Y_n(i,j)$:-

$$Yn(i,\ j) = \begin{cases} 1 & \text{if } Yn(i,\ j) \text{ is 0 or 255} \\ 0 & \text{if other} \end{cases} \quad \ldots\ldots(8)$$

3. The percentage of the impulse noise prediction is obtained by calculating percentage of the average value of $f_d(x,y)$:

$$p = \frac{1}{NM} \sum_{x=1}^{N} \sum_{y=1}^{M} Yn(i,\ j) * 100\ \% \ldots\ldots(9)$$

Where M= no. of Rows of Image
N = no. of Column in image

B. Noise Detector:-

Noise detector serves to detect the matrix elements of $Y_n(i,j)$ iare the noisy pixel or not. Following thing is done-
Matrix Element of $Y_n(i,j)$ = Noise, then Data filtered by pre filtering.
Matrix Element of $Y_n(i,j)$ = Noise Free, then Data forwarded to reconstruction part.

C. Pre-filtering:-

Before the filtering process is conducted, we set the value of each element noise, where "salt or 255" on be replaced by "0". So that, $Y_n(i,j)$ only has one noise model, that is "pepper or 0". We design PRE filter by linear filter. Linear Filter (LF) is designed from the blend between of the median and the average values on the free- noise pixels.

The median value of the free-noise has two possibilities (one pixel data or between two pixels). If the median value of the free-noise is between two pixels, then take the average value of both its pixels. The mathematical formulation of the median value of the free-noise (C_F) can be written as-

$$C_F = \begin{cases} w_f\left(\frac{N_f}{2}\right) & \text{if } N_f \text{ is odd} \\ w_f\left(\frac{N_f}{2}\right) + w_f\left(\frac{N_f}{2}+1\right) & \text{if } N_f \text{ is even} \end{cases} \quad \text{..........}(10)$$

Where N_f = No. of Noise-free pixels
W_f = Sample element data of Sorted noise-free pixels

VI. Simulation and Results

These methods are used to remove high density noise with image detail preservation because most of the algorithms produce good de-noising results at low noise density but they failed at high noise density. In this analysis, we have done image de-noising on Lena image of size 256x256 and simulate the results of different filters on MATLAB 10. For different high noise density levels (10%-90%), the resultant PSNR are shown in table II, and we made a comparative analysis based on this Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) of de-noised image. The results shown that, with the same noise density the different filter gives different results and produce better PSNR then other filters.

For the de-noised image Z of size M×N, the PSNR [2] will be

$$PSNR = 10\log_{10}\frac{(255)^2}{MSE} \text{.......}(11)$$

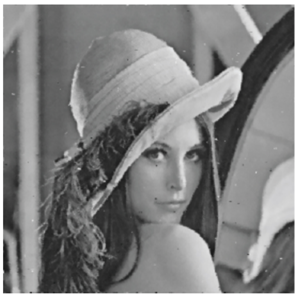
Where MSE (Mean square error), is

$$MSE = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\{Z(i,j)-Y(i,j)\}^2}{m\times n} \quad \text{..........}(12)$$

With respect to the noise-free original image Y.


(a) Original Lena Image


(b) Noisy Lena Image


(c). De-noised by ASMBF


(d). De-noised by DBA


(e). De-noised by LMMF

Fig.2. Lena Image De-noised by Different Filters

Table II shows the comparison PSNR result in many filtering methods which are Median Filter [8], Signal Dependent rank order mean filter (SD-ROM) [11], Linear Mean-Median filter (LMMF) [7], Decision-based Algorithm (DBA) [6], Adaptive Switching Median Based Filter (ASMBF) [4]. Table III shows the values of MSE for Different filters.

The figure 2 shows the results of different de-noised algorithms [1][3][6][7]on corrupted image.

VII. Conclusion

Our research paper presents impulse noise removal based on the Different median filters. The linear value is measured between mean and median values of the free-noise pixel that have been able to reduce impulse noise in the several variations of impulse noise density. Our methods attest that various filtering methods has the capability to reduce impulse noise across in varying ranges of noise 10% up to 90% in generally well. The success of LMMF to reduce impulse noise is measured by Qualitative and Quantitative parameters. Qualitative parameter is conducted by visual observation. Meanwhile, quantitative parameter is conducted by calculation of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error). LMMF has higher value than all other filters that indicates the filtering result almost close to the original image quality. Overall, the qualitative or quantitative testing of our new method shows significantly better image quality than MF, SD-ROM, DBA, and ASMBF. For next research, we will to apply and develop in the sequence image filters to reduce impulse noise densities.

Table II: Comparison result of PSNR value (decibel) of the Lena image

Methods	**Noise density *(P)* in % for Lena Image**								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
MF	28.7	26.4	22.6	18.3	15.0	12.2	9.8	8.1	6.5
SD-ROM	26.0	24.0	20.8	17.4	14.4	11.7	9.4	7.8	6.4
ASMBF	38.05	35.856	32.18	30.33	27.35	22.44	17.27	11.81	8.02
DBA	41.48	37.27	34.47	31.87	29.80	27.64	25.30	22.84	19.42
LMMF	42.93	39.38	37.11	34.97	33.34	31.37	29.41	26.77	23.55

Table III. Comparison result of MSE value of the Lena image

Methods	**Noise density *(P)* in % for Lena Image**								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
MF	87.71631	148.9637	357.339	961.7902	2056.271	3918.144	6808.953	10071.18	14557.28
SD-ROM	163.3354	258.8692	540.8544	1183.26	2360.9	4396.2	7465.8	10791.4	14896.3
ASMBF	10.1878	16.8842	39.36229	60.26711	119.6962	370.7493	1219.215	4286.278	10258.42
DBA	4.624666	12.19215	23.23167	42.27468	68.08953	111.9645	191.9024	338.1274	743.1566
LMMF	3.311924	7.50033	12.6497	20.70524	30.13564	47.43297	74.48698	136.7982	287.1312

REFERENCES

[1] Bhabesh Deka, Dipranjan Baishnab "A Linear Prediction Based Switching Median Filter, for the Removal of Salt and Pepper Noise from Highly Corrupted Image", CISP-2012, IEEE.

[2] Vikas Gupta and Abhishek Sharma "Image De-Noising by Enhanced Median Filtering for High Density Noisy Images", Proceedings of the Fourth International Conference on Signal and Image Processing 2012 (ICSIP 2012), Lecture Notes in Electrical Engineering 222, DOI: 10.1007/978-81-322-1000-9_55, _ Springer India 2013.

[3] V. Jayaraj, D. Ebenezer, V. R. Vijayakumar, "A Noise Free Estimation Switching Median Filter for Detection and Removal of Impulse Noise in Images", European Journal of Scientific Research ISSN 1450-216X Vol.51 No.4 (2011), pp.563-581.

[4] Gonzalez R.C, Woods. R.E., Digital Image Processing, 3rd edition, Pearson Prentice Hall, 2009.

[5] J.Harikiran, B.Saichandana, B.Divakar "Impulse Noise Removal in Digital Images", *International Journal of Computer Applications (0975 – 8887) Volume 10– No.8, November 2010.*

[6] Geeta Hanji, Dr. M. V. Latte, "An Improved Nonlinear Decision based Algorithm for Removal of Blotches and Impulses in Grayscale Images", Second International Conference on Advanced Computing & Communication Technologies. 2012 IEEE.

[7] Fitri Utaminingrum, Keiichi Uchimura and Gou Koutaki, "High Density Impulse Noise Removal based on Linear Mean-Median Filter", The 19th Korea -Japan Joint Workshop on Frontiers of Computer Vision, 2013 IEEE.

[8] James C Church, Yixin Chen, and Stephen V Rice , "A Spatial Median Filter for noise removal in digital images" ,IEEE Southeast Conference 2008,3-6 April 2008.

[9] Bo Fu, Kecheng Yang, Wei Li, Fan Fan, "A Salt & Pepper Noise Fast Filtering Algorithm for Grayscale Images Based on Neighborhood Correlation Detection", 2010 IEEE.

[10] S.Saudia, Justin Varghese, Krishnan Nallaperumal, Santhosh.P.Mathew, Angelin J Robin, S.Kavitha, "Salt & Pepper Impulse Detection and Median based Regularization using Adaptive Median Filter",

[11] E. Abreu, S.K. Mitra, A signal-dependent rank ordered mean (SD-ROM) filter. A new approach for removal of impulses from highly corrupted images, in: Proceedings of IEEE ICASSP-95, Detroit, MI, 1995, pp. 2371–2374.

AUTHOR'S PROFILE

Abhishek Sharma

did B.E. in Electronics and Communication from Technocrtas Institute of Technology, Bhopal (M.P.) India. He did M.Tech in Microelectronics & VLSI Design from Technocrtas Institute of Technology, Bhopal (M.P.) India. Presently He is working as Assistant Professor in Electronics and Communication department of Sagar Institute of Research & Technology, Bhopal (M.P.) India. He has published 1 Research Papers in International Conference ICSIP-2012 published In SPRINGER Lecture Notes Section. His area of interest is Image Processing.

Dr. Vijayshree Chaurasia

did B.E. in Electronics and Communication from Pt. Ravi Shanker University Raipur (C.G.) India. She did M.Tech in Digital Communication from Maulana Azad National Institute of Technology Bhopal (M.P.) India. She did Ph.D.in Electronics and Communication from MANIT Bhopal. Presently she is working as Assistant Professor in Electronics and Communication department of MANIT Bhopal. She has published around 25 Research Papers in National and International Journals of repute. Her area of interest is Image Processing and Communication. She is a member of professional bodies IEEE, ISTE and IETE.