Removal of Salt & Pepper & Gaussian Noise using Local Filters

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Abstract— Removing Salt & Pepper noise and Gaussian noise in digital images is one of the major challenges in image processing. For noise removal we are using different types of filters such as Mean, Median and proposed filter. It also highlights the comparable results between Mean, Median and proposed modified filter. The performance of the proposed method is analysed by using various parameters such as Mean Square Error (MSE), Peak Signal-to-Noise Ratio (PSNR), and Structural Similarity (SSIM). Simulation result shows that the proposed method performs well as compared to other filters.

Key words: Salt & Pepper Noise, Gaussian Noise, Mean Square Error (MSE), Peak Signal-to-Noise Ratio (PSNR), Mean Filter, Median Filter, Proposed Filter

I. INTRODUCTION

Digital images are used as valid information sources which are corrupted by noise when transmitted over the channel. There are various types of noise which can affect the images. For our experiment, we have considered Salt & Pepper noise and Gaussian noise. Filters that are having better edge & image detail preservation properties are desirable in image filtering [2]. For this various filtering techniques are used to remove noise from noisy images. There are many filters used to remove noise from images. In our experiment we are using Mean Filter, Median Filter and the proposed filter. Filters are used for de-noising the noisy image and get the noise free image at the output. The advantage of using Median filter is that it is effective when the noise density is below 20%, but its drawback is that when the noise density is more than 20%, the edges in the image details are lost [9]. All these filters have limitation in practice when it comes to filtering high noise densities. To overcome these drawbacks we have proposed a new modified mean filter. As in Mean Filter we move a 3 x 3 fixed size of window over the entire image by first shifting the window across the column of the image matrix and after that shifting it across the row of image matrix, so it will take more time to shift window over the entire image. So we proposed a modified mean filter in which the size of window increases as per requirement. For a given pixel, firstly, we enlarge its window size continuously until the maximum and minimum values of two successive windows are equal respectively. Secondly, the given pixel value will be replaced by the weighted mean of the current window if it equals the maximum or the minimum values, otherwise, it will be unchanged. The proposed filter has lower detection errors and better restoration image quality than other existing filters.

Figure.1 below show the basic block diagram:

It contains original image, noise adders, filters and we get output as a filtered image. The original images which we are taking are gray image and colour image. In Gray scale images each pixel value is normally from 0 (black) to 255 (white). In Colour images each pixel has a particular colour that colour being described by the amount of red, blue and green in it. Each of these components has a range 0-255. In our experiment we are dealing with two types noises such as Salt & Pepper noise, Gaussian Noise. Salt & Pepper noise is the form of noise in which image pixels are corrupted by white and black spots. These spots randomly appear in the image. If the image is affected by salt noise, it will have 255 values which appear to be white and if the image pixel is corrupted by pepper noise it will have 0 values which appear to be black.

Gaussian is caused by random fluctuation in the signal. The noise can be removed from images by using different types of filters. Mean Filter is an averaging linear filter, it replace each pixel value in an image with the mean value of its neighbours, including itself. This process is repeated for all pixel values in the image. Median Filter is quite popular for reducing the amount of intensity variation between one pixel and the other pixel. Here the centre value of the pixel is replaced by the Median of the pixel values under the filter.

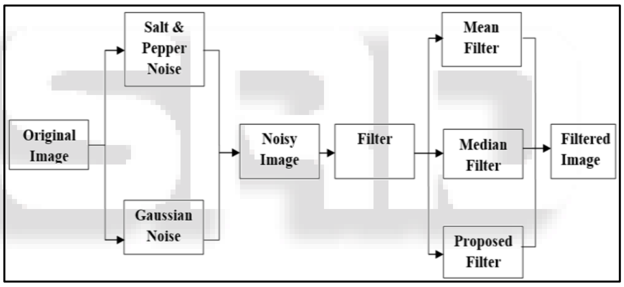


Fig. 1: Basic Block diagram

II. PROPOSED METHOD

We have used a Modified Mean Filter (MMF) method for detecting and removing high density salt-and-pepper noise from digital images. It firstly determines the adaptive window size by continuously enlarging the window size until the maximum and minimum values of two successive windows are equal respectively. Then the current pixel is regarded as noisy pixel if it is equal to the maximum or minimum values, otherwise, it is regarded as noise-free pixel. Finally, the noisy pixel is replaced by the weighted mean of the current window, while the noise-free pixel is left unchanged.

A. Algorithm

- Input: A digital image and add Salt & Pepper noise or Gaussian noise to that image.
- Output: Noise free image.
- The steps for our algorithm are as follows:

1) Step 1: Select a 3 x 3 2-D window, assuming that the processing pixel is Pij.
2) Step 2: If 0<Pij<255, then the processing pixel or Pij is uncorrupted and left unchanged.

3) Step 3: If Pij=0 or Pij=255, then it is considered as corrupted pixel and four cases are possible as given below:
   - Case i) If the selected window has all the pixel value as 0, then the Pij is replaced by the Salt noise (i.e. 255).
   - Case ii) If the selected window has all the pixel value as 255, then the Pij is replaced by the Pepper noise (i.e. 0).
   - Case iii) If the selected window contains all value as 0 and 255 both. Then processing pixel is replaced by mean value of the window.
   - Case iv) If the selected contains not all the value as 0 and 255. Then eliminate 0 and 255 and find the mean value of the remaining element. Replace Pij with mean value.
4) Step 4: Repeat step 1 to 3 for the entire image until the process is complete.

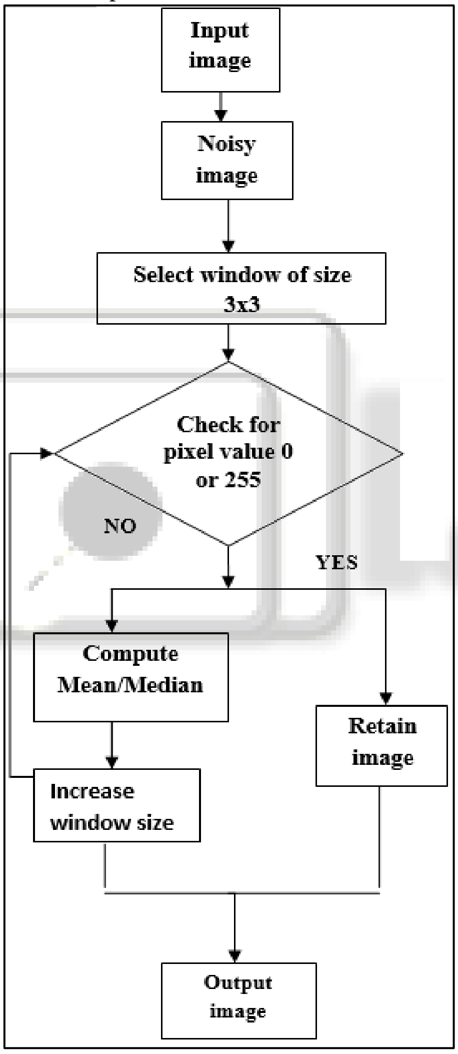


Fig. 2: Flow Chart of Proposed Filter

III. EXPERIMENTAL RESULT & ANALYSIS

In our experiment we have taken an image namely cameraman from a publicly available database. In the simulation, images are corrupted by salt & pepper noise and Gaussian noise with equal probability. A wide range of noise density from 0.4, 0.5, 0.6, 0.8 and 0.9 are added to the image. De-noising performance is quantitatively measured by the conventional Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Structural Similarity (SSIM). For better comparison of image quality, PSNR should be high and MSE should be low.

A. Mean Square Error (MSE)

The Mean Square Error (MSE) is the cumulative square error between the reconstructed and the original image defined by the formula given below:-

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|f(i,j) - g(i,j)\|^2$$

Where, f is the original image and g is the filtered image.

The Mean Square Error (MSE) for our practical purposes allows us to compare the pixels of original image to our restored or filtered image.

B. Peak Signal to Noise Ratio (PSNR)

The Peak Signal to Noise Ratio (PSNR) is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The PSNR is defined as:

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$

Where, MAX_I is the maximum possible pixel value of the image.

C. Structural Similarity (SSIM)

Structural Similarity (SSIM) is used for measuring the similarity between two images. It is designed to improve on traditional methods such as peak signal-to-noise ratio (PSNR) and mean squared error (MSE).

SSIM is used for measuring similarity between two images X and Y.

$$SSIM(X, Y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

Where, μ_x is the average of x,
μ_y is the average of y
σ_x^2 the variance of x
σ_y^2 the variance of y
σ_{xy} the covariance of x and y
$c_1 = (k_1L)^2$, $c_1 = (k_2L)^2$ two variables to stabilize the division with denominator,
L the dynamic range of the pixel values

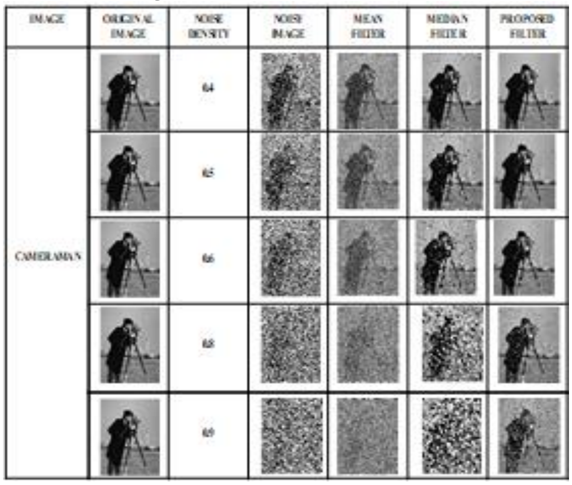
D. Evaluation

The performance of different methods is summarized in fig.3 out of which the proposed filter is better as compared to other filters when the noise density is low. However, when the noise density increases, the performance of mean filter and median filter degrades.

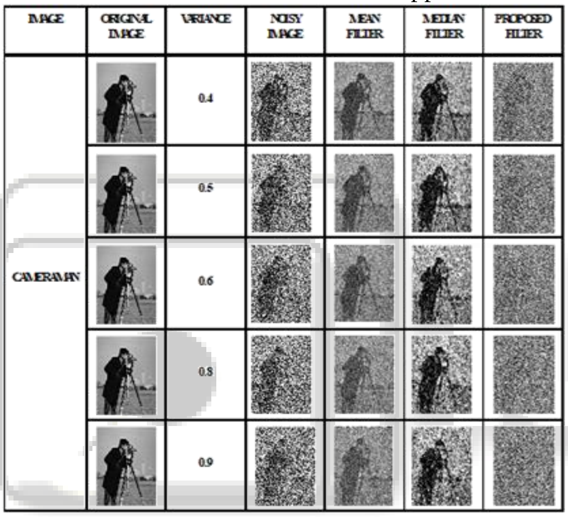
The proposed filter achieves a significantly low MSE, high PSNR and high SSIM even the noise density is high with comparison to mean filter and median filter.

The restoration result is shown in fig.4 for the noise density of 0.4, 0.5, 0.6, 0.8, and 0.9 for cameraman image. Among all these filters, the proposed filter gives best performance in terms of noise suppression and detail preservation.

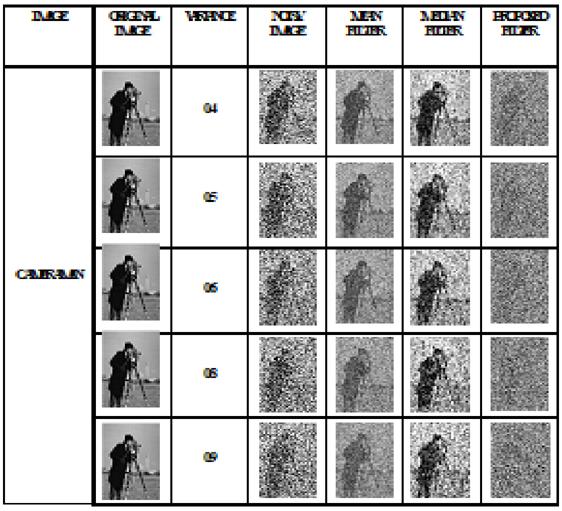
Using modified mean filter we are able to remove some amount of noise but a large amount of noisy pixels are present in the image.



For Various Densities of Salt & Pepper Noise



For Mean=0 and Various Values of Variance of Gaussian Noise



For mean=0.1 and various values of variance of Gaussian noise

Fig. 3 (a) (b) and (c) Results for corrupted cameraman image (Gray image) for removal of noise using different types of filters such as mean, median and proposed modified mean filter

Table for MSE, PSNR, and SSIM at different noise densities of Salt & Pepper noise and Gaussian noise for Gray images

IMAGE	TYPE OF NOISE	NOISE DENSITY	MEAN FILTER	MEDIAN FILTER	PROPOSED FILTER
CAMERAMAN (GRAY IMAGE)	SALT & PEPPER NOISE	0.4	89.57	24.02	12.50
		0.5	97.36	28.60	15.52
		0.6	102.28	38.51	19.88
		0.8	110.73	61.11	37.12
		0.9	113.78	88.54	60.67
	GAUSSIAN NOISE Mean=0	0.4	96.46	94.81	109.23
		0.5	98.78	98.01	109.79
		0.6	100.71	101.14	109.72
		0.8	103.03	108.93	112.06
		0.9	104.12	105.44	110.67
	Mean=0.1	0.4	66.27	56.44	103.03
		0.5	71.97	61.81	104.10
		0.6	73.62	62.98	107.20
		0.8	80.87	71.31	108.09
		0.9	83.48	69.50	107.92

Table 1: MSE Values of Different Filter at Different Noise Density

IMAGE	TYPE OF NOISE	NOISE DENSITY	MEAN FILTER	MEDIAN FILTER	PROPOSED FILTER
CAMERAMAN (GRAY IMAGE)	SALT & PEPPER NOISE	0.4	25.82	33.35	34.37
		0.5	25.55	33.42	35.90
		0.6	27.39	32.63	35.00
		0.8	27.05	30.12	31.15
		0.9	27.43	28.84	29.66
	GAUSSIAN NOISE Mean=0	0.4	25.45	26.71	27.14
		0.5	27.87	27.35	27.34
		0.6	26.45	27.44	27.16
		0.8	25.36	27.04	27.35
		0.9	25.62	27.37	27.12
	Mean=0.1	0.4	27.17	30.47	27.68
		0.5	26.81	29.90	27.35
		0.6	29.32	29.16	26.81
		0.8	28.91	28.31	27.65
		0.9	27.31	28.85	27.16

Table 2: PSNR Values of Different Filter at Different Noise Density

IMAGE	TYPE OF NOISE	NOISE DENSITY	MEAN FILTER	MEDIAN FILTER	PROPOSED FILTER
CAMERAMAN (GRAY IMAGE)	SALT & PEPPER NOISE	0.4	0.18	0.65	0.87
		0.5	0.15	0.51	0.83
		0.6	0.11	0.34	0.77
		0.8	0.07	0.07	0.42
		0.9	0.04	0.02	0.18
	GAUSSIAN NOISE Mean=0	0.4	0.15	0.14	0.03
		0.5	0.13	0.12	0.03
		0.6	0.13	0.11	0.03
		0.8	0.11	0.09	0.03
		0.9	0.10	0.09	0.02
	Mean=0.1	0.4	0.14	0.13	0.03
		0.5	0.13	0.11	0.03
		0.6	0.12	0.11	0.03
		0.8	0.11	0.09	0.02
		0.9	0.10	0.09	0.02

Table 3: SSIM Values of Different Filter at Different Noise Density

IV. CONCLUSION

The conclusion drawn from the above experiment is that proposed modified mean filter gives better result with higher intensity of noises. It is observed that the Mean square error (MSE), Peak-Signal-to-Noise-Ratio (PSNR) and Structural Similarity (SSIM) parameters gets improved while using modified mean filter as compared with Mean and Median filter respectively. The above concept works best with salt & Pepper noise which is random in nature and is most frequently occurring on transmitted images. At high noise densities the texture details and edges are preserved to an acceptable level.

The same experiment is tried out with Gaussian noise varying its mean and variance for various noise levels. The improvement in values of MSE, PSNR and SSIM is obtained for images with less noise density. With higher density noise images the proposed algorithms do not work sufficiently well.

Hence with higher density noise images the proposed filter need to be modified in case of Gaussian noise.

V. FUTURE SCOPE

In future the improved mean filter can be used for removing different types of noises such as exponential noise, speckle noise etc. depending upon the requirement of the application. Also different types of parameters for analysis can also be considered for different types of filters such as Mean absolute error etc.

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REFERENCES

[1] Jayanta Das, Bhaswati Das, Jesmine Saikia and S.R.Nirmala, “Removal of Salt and Pepper Noise Using Selective Adaptive Median Filter”, International Conference on Accessibility to Digital World (ICADW), Conference date 16-18 Dec. 2016, © IEEE.
[2] Raghuram Kunsoth and Mantosh Biswas, “Modified Decision Based Median Filter for Impulse Noise Removal”, International Conferecence on Wireless Communications, Signal Processing and Networking (WiSPNET), 2016.
[3] Pei-Eng Ng and Kai-Kuang Ma, Senior Member, IEEE, “A Switching Median Filter With Boundary Discriminative Noise Detection for Extremely Corrupted Images”, IEEE Transactions on image processing, vol.15, no. 6, June 2006.
[4] Mr. N. Krishna Chaitanya and Mr.P.Sreenivasulu, “Removal of Salt and Pepper Noise Using Advanced Modified Decision Based Unsymmetric Trimmed Median Filter”, International Conference on Electronics and Communication Systems (ICECS), 2014.
[5] Archana Singh, Sanjana Yadav and Neeraj Singh, “Contrast Enhancement and Brightness Preservation using Global-local Image Enhancement Techniques”, Fourth International Conference on Parallel, Distributed and Grid Computing (PDGC), 2016.
[6] Zhou Wang and David Zhang, “Progressive Switching Median Filter for the Removal”, IEEE Transactions on circuits and systems—II: Analog and digital signal processing, vol. 46, NO. 1, January 1999.
[7] Soon Ting Boo, Haidi Ibrahim and Kenny Kal Vin Toh, “An Improved Progressive Switching Median Filter”, International Conference on Future Computer and Communication, 2009.
[8] S. Esakkirajan, T. Veerakumar, Adabala N. Subramanyam, and C. H. PremChand, “Removal of High Density Salt and Pepper Noise Through Modified Decision Based Unsymmetric Trimmed Median Filter”, IEEE Signal Processing Letters, vol.18, no.5, May 2011.
[9] Thomas A. Nodes and Neal C. Gallagher, “Median Filters: Some Modifications and Their Properties”, IEEE Trans. Acoust., Speech and Signal Processing, vol. ASSP-30, pp.739-746, April 1987.
[10] T. Loupas, W. N. Mcdicken, and P. L. Allan, “An Adaptive Weighted Median Filter for Speckle Suppression in Medical Ultrasonic Images”, IEEE Transactions Circuit Systems, Vol. 36, No. 1, pp. 129-135, 1989.
[11] Sung-Jea KO and Yong Hoon Lee, “Center Weighted Median Filters and Their Applications to Image Enhancement”, IEEE Transactions on circuits and systems, vol.38, No. 9, pp. 984-993, 1991.
[12] Shuqun Zhang and Mohammad A. Karim, “A New Impulse Detector for Switching Median Filters”, IEEE Signal Process. Lett, vol.9, no.11, pp.360-363, Nov.2002.
[13] K. S. Srinivasan and D. Ebenezer, “A New Fast and Efficient Decision-Based Algorithm for Removal of High-Density Impulse Noises”, IEEE Signal Processing, Letter, vol.14, no.3, pp.189-192, March 2007.
[14] H. Chan, Chung-Wa Ho, and Mila Nikolova, “Salt-and-Pepper Noise Removal by Median-type Noise Detectors and Detail-preserving Regularization”, IEEE Transactions on Image Processing, vol.14, no. 10, pp.1479-1485, oct. 2005.

