International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 4 Issue 5, May-2015, pp: (30-36), Impact Factor: 1.252, Available online at: www.erpublications.com

Decision based expanding window unsymmetrical trimmed median filter using last processed pixels high density salt & pepper noise removal using median filter using multiple scanning

Megha Goel

Dept. of Electronics & Communication Engg., SBIET, Pundri, Haryana, India

Abstract: A new technique of image filtering, for the images corrupted by high density salt & pepper noise, is presented in this paper. Proposed algorithm makes a decision about the noisy or noise free pixel for its further processing. Then it selects a window and chooses the noise free neighbors from this window for median calculation. And if sufficient numbers of noise free pixels ar not found it expands the window for further processing. And if in the first phase of the algorithm it does not find the sufficient number of pixels for median calculation then it does not process it and in the next phase it uses the concept of last processed pixels for the median calculation. The algorithm is tested for many standard and non standard images and found its performance better than the existing techniques of filtering in terms of PSNR, SSIM and IQI.

Keywords: Median Filter, Salt & Pepper noise, Decision based filter.

Introduction

Digital Images are often corrupted by impulse noise during image acquisition, during storage and during transmission. This impulse noise degrades the quality of images. Impulse noise can damage the information stored in original image pixels. So restoration of any corrupted image is very important before any type of processing such as edge detection, image segmentation or image recognition. Two types of impulse noise are salt and pepper noise and random valued noise. The noisy pixels corrupted with salt and pepper noise can take only two intensity values either maximum or minimum values of gray level within the dynamic range i.e. 0 or 255 in 8-bit gray scale image [1].

A wide variety of non linear filtering techniques like median filters have been implemented for the restoration of digital images affected by salt and pepper noise. Median filters replace the value of a pixel by median of neighborhood pixel values. Median filters use a filtering window for selecting neighborhood pixels. However standard median filters (SMFs) are implemented uniformly across the image and thus tend to modify both noisy and noise free pixels [2]. So there is a chance of replacement of good pixels by some corrupted ones. So SMF causes blurring for large window sizes. And for small window sizes SMF doesn't work effectively. In this paper an algorithm is presented which gives better results than existing techniques of median filtering and restores the digital image even affected by high density salt and pepper noise.

Related Work

Standard Median Filter is only effective for low density noise and exhibits blurring of the filtered image if the window size is large. For noise level over 50% it fails to preserve the edge details of the original image [3]. In Adaptive Median Filter [4], a noise detection process is followed to distinguish between the noisy and noise free pixels. But AMF perform well at low noise densities. But at high noise densities the window size has to be increased which may lead to blurring the image. The difference between the AMF and the SMF is that, the SMF uses the fixed window size and the AMF changes the window size during the filtering. If the value of the median in the selected window is noisy then the window size is increased. In a Decision Based Algorithm [5] window size of 3 X 3 is used for restoring a noise affected image. In this algorithm, if the processing pixel is corrupted then it is processed otherwise it is left unchanged. At high noise density median of a window is also noisy and processing pixels is replaced by neighboring pixel value. It produces streaking effect at high noise density.An improved Decision Based Algorithm [7] uses previously processed neighboring pixel values to get better image quality of highly corrupted gray scale and colored images. If the median value of the selected window is noisy, then, the processing pixel value is replaced by the mean of the already processed pixels in the selected window.

A Modified Decision Based Unsymmetrical Trimmed Median Filter [8] trims the noisy values in the selected window and replaces the processing noisy pixel the median value of remaining noise free pixels in the window. And if all the pixel values are noisy in the selected window then the processing noisy pixel is replaced by mean value of the selected window. It uses a fixed window of size 3 X 3. At high noise densities a dark surface is found in the restored images due to the replacement of the pixel values by the mean of noisy pixels. In a decision-based coupled window median filter (DBCWMF) algorithm [9], the problem of dark surface at high noise densities is removed by using the variable window size. By using the increasing dimension window, more noise-free pixels are found. This algorithm starts with the window size of 3 X 3 to get the noise free pixels, and if all the pixels in the selected window are noisy then window size is increased to 5 X 5.

Proposed Algorithm

In decision-based coupled window median filter (DBCWMF) algorithm [9] at very high noise densities, the probability of all the pixels, of selected window of maximum size, are noisy is very high. And in this case the processing pixel (center noisy pixel) is replaced by the mean of the all noisy pixels in the selected window due to which a dark patch like surface is created in the de-noised image at high noise densities. In the proposed algorithm this problem is eliminated by replacing this noisy pixel value by the median of the last processed pixels in the selected window. So the image is scanned with the proposed algorithm in both forward and backward directions to get the whole of the pixels in the selected window as the last processed pixels. The Proposed Algorithm processes the noisy image in three phases. In first phase it scans the image in forward direction i. e. starts from 1^{st} pixel of the image and moves towards the last pixel. The restored image from the 1^{st} phase of the image is considered as the noisy image for the 2^{nd} phase of the proposed algorithm. And in 2^{nd} phase of the algorithm, it scans the image in backward direction i.e. it starts from the last pixel of the image and moves towards the first pixel. The restored image from the 2^{nd} phase is again scanned in the 3^{rd} phase. Now in this phase for every processing pixel (center noisy pixel) in the selected window, all the neighbor pixels in the window are last processed pixels. And if out of these neighbor pixels $3/4^{th}$ pixels are noise free then the processing pixel is replaced by the median of these last processed pixels otherwise again the processing pixel is replaced by the mean of the selected window. The detailed steps of the proposed algorithm are given below:

Phase 1:

Step 1: Read the noisy Image.
Step 2: Start scanning and processing of the image pixels in forward direction i.e. start from the 1^{st} pixel and move towards the last pixels.
Step 3: Do zero padding of this noisy image so that the edges of the image can be processed. Maximum window size used in the proposed algorithm is 7 X 7. So 3 rows and 3 columns are padded to the edges of the image.
Step 4: Make decision for the processing pixel that whether it is noisy or noise free. If the processing pixel is found noise free then it is assigned to the denoised image as it is without any processing and then move to the next pixel.
Step 5: if the processing pixel is found noisy then initialize n with value 1.
Step 6: Select a window 'W' of size (2n+1) X (2n+1) considering the processing pixel P(i,j) as a center pixel of the selected window.
Step 7: If noisy pixels are less than the $3/4^{th}$ of the total pixels in the selected window then median filtering operation is performed by removing all the noisy pixels from the selected window and finding out the median of the remaining pixels. The processing pixel P(i,j) (center noisy pixel) value is replaced by this calculated median value and assigned to denoised image.
Step 8: If noisy pixels are more than the $3/4^{th}$ of the total pixels in the selected window then the filtering operation is not performed on the selected window and size of the window is increased by incrementing the value of n by 1.
Step 9: To search the more noise free pixels this size of window is increased up to the value of n<4. If value of n is less than 4 then go to step 6.
Step 10: If value of n is more than 4 and still sufficient number of noise free pixels is not obtained in first three windows for median calculation then the processing pixel (center noisy pixel) is not processed in this phase of algorithm and value of this pixel is remained noisy as it is and assigned to the denoised image.
Step 11: Repeat from step 4 to step 10 to process till the last pixel of the image. And get the denoised image from phase 1 of the algorithm.

Phase 2:

Here the denoised image collected in phase 1 is considered as input/noisy image for phase 2 and is processed with all the basic steps described in phase 1. The only difference in phase 1 and phase 2 is that the in phase 2 the image scanning is done in reverse direction i.e. scanning starts from the last pixel of the image and moves towards the first pixel. And then the whole process described from step 3 to step 11 in phase 1 is implemented to get the denoised image from phase 2 of the algorithm.

Phase 3:

Here the denoised image collected in phase 2 is considered as input image for processing in phase 3. In this phase of processing when any pixel is processed and it is found still noisy then in the selected window for its processing all the neighbor pixels are said to be last processed pixels as they are already processed in first two phases. Select a processing pixel and process it as described in following steps.

Step 1: Process the selected pixel with the step 4 to step 9 in phase 1.
Step 2: If n reaches its maximum value i.e. the maximum permitted window is reached and still noisy pixels are more than the $3/4^{th}$ of the total pixels in the selected window then the processing pixel (center noisy pixel) is replaced by the mean of the whole pixels of the selected window and assigned to the denoised image.
Step 3: Move to the next pixel.
Step 4: Repeat from step 1 to step 3 to process the whole image pixels till the last. And get the final restored image of the proposed algorithm.

EXPERIMENTAL RESULTS AND PERFORMANCE EVALUATION

MATLAB 7.10.0 is used as the platform for implementing the proposed work & conducting experiments. The performance of the proposed image restoration algorithm is evaluated using many RGB and gray scale images. But here the results are discussed with only the standard RGB image of Lena of size 512 X 512 X3 and standard grayscale image of cameraman of size 512 X 512. And also the proposed algorithm is compared with some existing algorithms of median filtering. The algorithm is tested under various noise densities of 10% to 90%. To prove the denoising performance of proposed algorithm, as a measure of quality of the restored image Mean Squared Error (MSE), Peak Signal to Noise Ratio (PSNR), Bit Error Rate (BER), Structural Similarity Index Metric (SSIM), and Image Quality Index (IQI) is calculated using equations (1), (2), (3), (4), and (5) respectively. The values for these parameters are tabulated in table 1 and table 2 for the processed noisy image of Lena and cameraman respectively with Proposed Algorithm at various noise densities.

$$\mathrm{MSE} = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j) - y(i,j))^2 \quad \text{--(1)}$$

Where, x is original image of size M X N and y is restored image of same size.

$$\mathrm{PSNR} = 10\log_{10}\frac{255}{\sqrt{\mathrm{MSE}}} \quad \text{-- (2)}$$

$$\mathrm{BER} = \frac{1}{\mathrm{PSNR}} \quad \text{---(3)}$$

$$\mathbf{SSIM(x,y)} = \frac{(2\bar{x}\bar{y} + C1)(2\sigma_{xy} + C2)}{((\bar{x})^2 + (\bar{y}^2) + C1)(\sigma_x{}^2 + \sigma_y{}^2 + C2)} \quad \text{--(4)}$$

The SSIM metric is calculated on various windows of any image. The measure between two windows x and y of common size N×N is given by above equation.

Where C1 & C2 are constants. $\bar{\mathbf{x}}, \bar{\mathbf{y}}, \boldsymbol{\sigma}_{\mathbf{x}}{}^{\mathbf{2}}, \boldsymbol{\sigma}_{\mathbf{y}}{}^{\mathbf{2}}$ and $\boldsymbol{\sigma}_{\mathbf{xy}}$ are given as:

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

$$\bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i$$

$$\sigma_x^{\,2} = \frac{1}{N-1}\sum_{i=1}^{N}(x-\bar{x})^2$$

$$\sigma_y^{\,2} = \frac{1}{N-1}\sum_{i=1}^{N}(y-\bar{y})^2$$

$$\sigma_{xy} = \frac{1}{N-1}\sum_{i=1}^{N}(x-\bar{x})(y-\bar{y})$$

SSIM value closer to 1 represents the better quality of the restored image.

IQI = Crr(x, y) X L(x, y) X C (x, y) --- (5)

Where, Crr(x, y) is correlation between the original image x and restored image y, L(x,y) is luminous distortion between both images and C(x, y) is the contrast distortion. The minimum value of IQI can be -1 and its maximum value can be 1. Closer the value to 1 better is the quality of restored image. As already described, the algorithm has 3 phases. Figure 1 shows the phase wise simulation results of proposed algorithm applied to the cameraman image affected by salt & pepper noise of 70% density. Figures 2 to 10 shows RGB Lena image corrupted at various noise densities from 10% and 90% and their corresponding restored images with the proposed algorithm.

Table 1: MSE, PSNR, BER, SSIM, and IQI for proposed algorithm for Lena image at various noise densities

	Noise Densities (in percentage)								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
MSE	0.5019	1.0676	1.7284	2.4502	3.2537	4.1785	5.3478	7.3488	25.3147
PSNR	51.1248	47.8466	45.7542	44.2389	43.0070	41.9206	40.8491	39.4687	34.0971
BER	0.0196	0.0209	0.0219	0.0226	0.0233	0.0239	0.0245	0.0253	0.0293
SSIM	0.9962	0.9916	0.9857	0.9787	0.9687	0.9553	0.9334	0.8716	0.2971
IQI	0.9718	0.9399	0.9029	0.8614	0.8126	0.7571	0.6850	0.5677	0.1325

Table 2: MSE, PSNR, BER, SSIM, and IQI for proposed algorithm for cameraman image at various noise densities

	Noise Densities (in percentage)								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
MSE	0.8497	1.9510	3.2584	4.8051	6.7716	9.0582	12.5615	17.5830	59.9246
PSNR	48.8382	45.2282	43.0008	41.3138	39.8239	38.5604	37.1404	35.6799	30.3547
BER	0.0205	0.0221	0.0233	0.0242	0.0251	0.0259	0.0269	0.0280	0.0329
SSIM	0.9991	0.9976	0.9952	0.9912	0.9848	0.9733	0.9513	0.8848	0.2727
IQI	0.9984	0.9979	0.9899	0.9957	0.9814	0.9789	0.9719	0.9781	0.8217

International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 4 Issue 5, May-2015, pp: (30-36), Impact Factor: 1.252, Available online at: www.erpublications.com

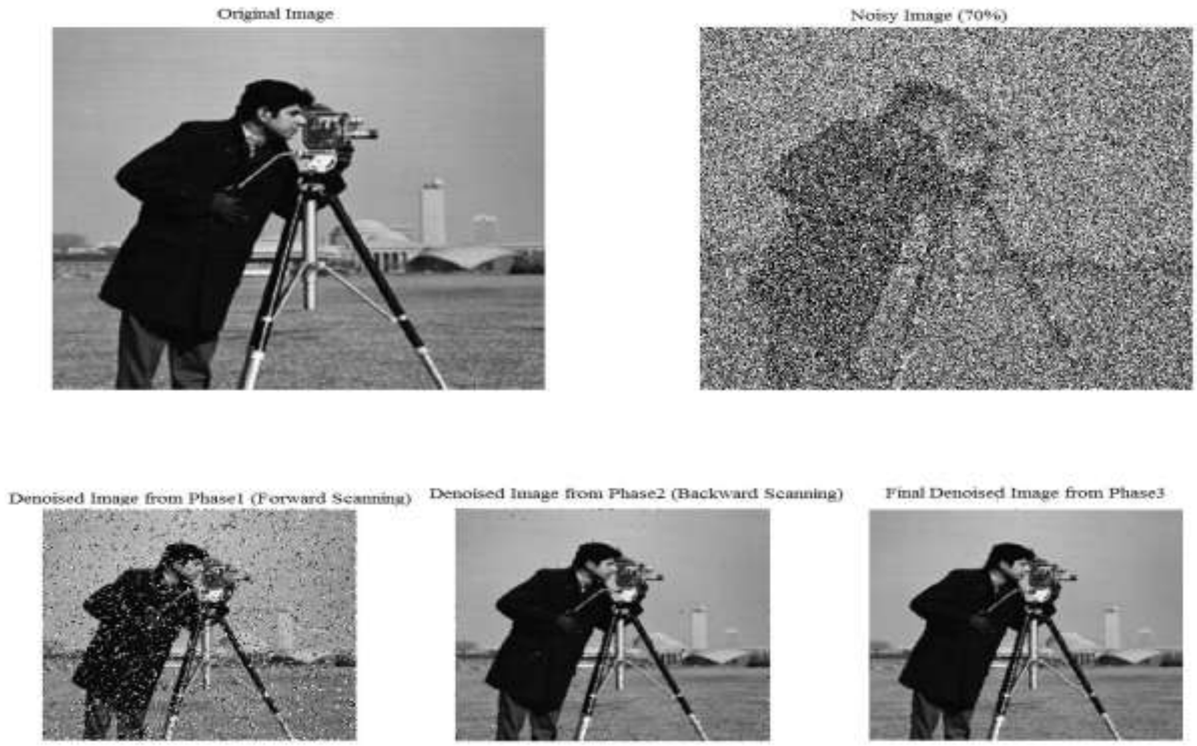

Figure 1: Phase wise results of proposed algorithm applied to the cameraman image at 70%

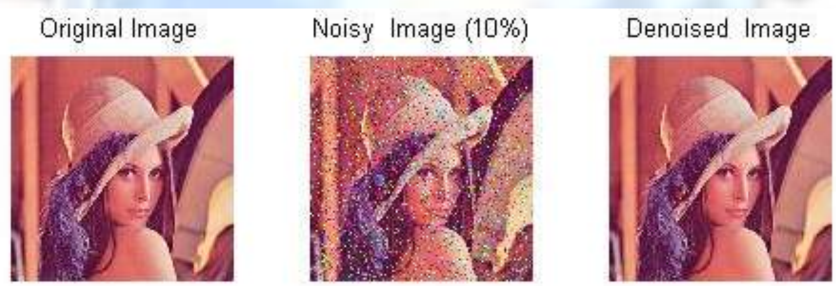

Figure 2: Simulation results of proposed algorithm applied to the RGB Lena image at 10%

Figure 3: Simulation results of proposed algorithm applied to the RGB Lena image at 20%

International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 4 Issue 5, May-2015, pp: (30-36), Impact Factor: 1.252, Available online at: www.erpublications.com

Figure 4: Simulation results of proposed algorithm applied to the RGB Lena image at 30%

Figure 5: Simulation results of proposed algorithm applied to the RGB Lena image at 40%

Figure 6: Simulation results of proposed algorithm applied to the RGB Lena image at 50%

Figure 7: Simulation results of proposed algorithm applied to the RGB Lena image at 60%

Figure 8: Simulation results of proposed algorithm applied to the RGB Lena image at 70%

Figure 9: Simulation results of proposed algorithm applied to the RGB Lena image at 80%

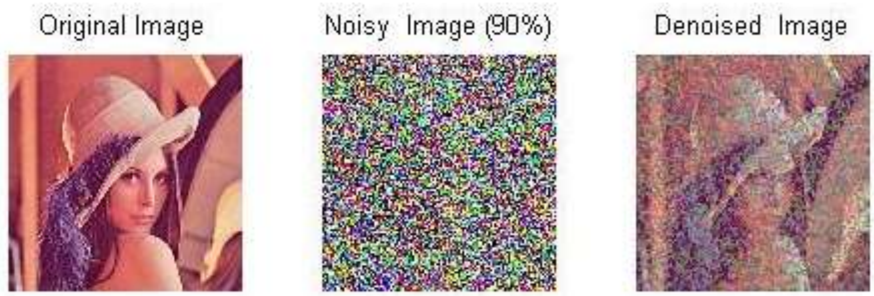

Figure 10: Simulation results of proposed algorithm applied to the RGB Lena image at 90%

Conclusion

In this paper, an enhanced image restoration method is proposed for the images corrupted with high density salt & pepper noise. The proposed algorithm works in three phases. In first phase algorithm scans the image in forward direction finds the corrupted pixels and process them with algorithm steps and median filtering. In second phase algorithm scans the image in backward direction finds the corrupted pixel s and process them with algorithm steps and median filtering. In the last phase of the algorithm if it does not find the proper number of elements in the selected window for median calculation, then it replaces the value of processing pixel with the mean of the selected window.

The proposed algorithm gives far better results than the existing techniques of the median filtering at any noise density. As the algorithm creates more noise free pixels in two phases and in the third phase for every processing pixel in any selected window whole the neighbor pixels are last processed pixels. And chances of getting pixels for median calculation are very high. The algorithm is tested on various standard and non standard real time images and is proved that the algorithm is better than the existing ones in terms of high PSNR, and SSIM and low BER.

References

[1]. Kenny Kal Vin Toh, and Nor Ashidi Mat Isa, "Noise Adaptive Fuzzy Switching Median Filter for Salt-and-Pepper Noise Reduction," IEEE Signal Processing Letters, Vol. 17, No. 3, March, 2010, pp-281-284.

[2]. Astola, J., Kuosmaneen, P.: Fundamental of Nonlinear Digital Filtering. CRC, Boca Raton (1997)

[3]. Chan, R.H., Ho, C.W., and Nikolova, M.,"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.

[4]. H. Hwang and R. A. Hadded, "Adaptive median filter: New algorithms and results," IEEE Trans. Image Process., vol. 4, no. 4, pp. 499 502, Apr. 1995

[5]. K. S. Srinivasan and D. Ebenezer, "A new fast and efficient decision based algorithm for removal of high density impulse noise," IEEE Signal Process. Lett., vol. 14, no. 3, pp. 189–192, Mar. 2007.

[6]. V. Jayaraj and D. Ebenezer, "A new switching-based median filtering scheme and algorithmfor removal of high-density salt and pepper noise in image," EURASIP J. Adv. Signal Process., 2010.

[7]. Madhu S. Nair, K. Revathy, and Rao Tatavarti, "Removal of Salt-and Pepper Noise in Images: A New Decision-Based Algorithm", Proceedings of the International MultiConference of Engineers and Computer Scientists, Vol 1, March 2008

[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 2005.

[9]. Vivek Singh Bhadouria, Dibyendu Ghoshal, Abul Hasan Siddiqi, "A new approach for high density saturated impulse noise removal using decision-based coupled window median filter", Springer, June 2013.