Removal of High Density Impulse Noise using Efficient Median Filter for Digital Image

Prateek Agrawal[1], Prof. Dharmendra Sharma[2]
Researcher[1], Guide[2] Electronics & Communication Department, R.G.P.V. University
Sushila Devi Bansal College of Engineering Indore M.P., India
prat9agrawal@gmail.com[1]

Abstract: **An Efficient Median Filter (EMF) algorithm for removal or enhancement of gray scale images are highly corrupted impulse noise is proposed in this paper. Noise in image are represent the pixel value 0's and 255's are ensures that black and white dot in image. In proposed algorithm take an image and select 3x3 size window and target or center pixel value check if its value is 0's or 255's then image is corrupted otherwise noise free image. If image is noisy and target pixels neighboring pixel value is between 0's and 255's then we replace pixel value with the median value and if target pixels neighboring pixel value is 0's or 255's then we replace pixel value with the mean value. Else increased the window size and again repeat this process until image is denoised. The proposed filter algorithm shows better simulation result as compare the existing algorithms. The simulation result shows better and efficient performance of PSNR and MSE and computation time.**

Keywords: **Salt and pepper noise, peak signal noise ratio, image enhancement factor, mean square error, mean absolute error.**

I INTRODUCTION

Impulse noise is caused by malfunctioning pixels in camera sensors, faulty memory locations in hardware, or transmission in a noisy channel. Two common types of impulse noise are the salt-and-pepper noise and the random valued noise. For images corrupted by salt-and-pepper noise (respectively random-valued noise), the noisy pixels can take only the maximum and the minimum values (respectively any random value) in the dynamic range. There are many works on the restoration of images corrupted by impulse noise. The median filter was once the most popular nonlinear filter for removing impulse noise, because of its good denoising power and computational efficiency. Over the last two decades, there is a significant improvement in the development of median filters. The presence of salt-and-pepper noise in digital image can severely damage image details and information. Therefore, removal of this type of noise is an important issue in order to perform further processing on an image and it is critical for the extraction of reliable and accurate information from a digital image [5]. Nonlinear filtering techniques are implemented widely because of their superior performance in removing salt and-pepper and also preserving fine details of image while linear filters perform weakly and create blurring effect. Several researches on this area have been done to modify non-linear filters and to develop more efficient algorithm in removing this kind of noise from a digital image.

In this paper, a developed algorithm has been proposed which exhibits better result than some recent techniques. In the next few sections of this paper, a study on the recently developed works will be discussed including some traditional adaptive filtering techniques as well. After that the proposed technique will be illustrated in details with the performance analysis followed by that.

Different filters uses different sorting algorithm like merge sort, quick sort, heap sort to sort the elements of window. Some techniques focused on noise detection, so there are different techniques to find out that the pixel is noisy or noiseless, so that only noisy pixel will be replaced by the median value and noiseless pixel will be unaffected. These techniques reduce the processing time and also improve the quality of image. In the proposed algorithm we have improved the technique of noise detection by improving the threshold value. We have used two threshold values (maximum=255 and minimum=0), so there is easy to detect the random valued impulse noise.

The first and second stages are connected in cascade. The denoising capability of these cascading algorithms also fails at high noise density. To overcome this drawback new Cascading algorithms are proposed in this paper. These cascading algorithms efficiently remove the noise at low, medium and high noise level. These also enhance the image quality at high noise level very effectively as compared to the all previous algorithms. These algorithms consist of two stages. The first stage is one of the two algorithms i.e. either Modified Decision Base Partial Trimmed Global Mean Filter (MDBPTGMF) or Modified Decision Base Unsymmetric Trimmed Median Filter (MDBUTMF). The main objective of the second stage is to remove the noise and increase the image quality at all noise level. Second is Decision base Median Filter (DMF) [7] which detects and replaces the corrupted pixels with median value while uncorrupted pixels are left unchanged. These two stages are connected in cascade form. Proposed algorithm PA1 (MDBPTGMF+DMF) produces a consistent result from low to high noise level and it outperforms the previous algorithms at high noise density and Proposed algorithm PA2 (MDBUTMF+DMF) produces excellent result from low to high noise level in terms of PSNR, MAE and IEF as compared to all other algorithms.

The rest of the paper is structured as follows. The proposed algorithms and its different cases are described in section II. Simulation results are presented in section III. Finally conclusions are drawn in section IV.

II. PROPOSED ALGORITHMS

A. Stage-1

The stage-1 of the proposed cascading algorithm is one of the two algorithms given below.

i. Modified Decision Based Partial Trimmed Global Mean Filter (MDBPTGMF)

The Modified Decision Based Partial Trimmed Global Mean Filter or MDBPTGMF algorithm is a variation to Decision Base Partial Trimmed Global Mean Filter or DBPTGMF algorithm. The major drawback of DBPTGMF algorithm [6], is when a selected window contains only 0 and 255 value then the restored value is either 0 or 255(again noisy), leads us to propose MDBPTGMF. In this algorithm when a selected window contain both the 0 and 255 values then the processing pixel is replaced by mean value of the selected window. The detail of the algorithm is given below.

Algorithm:

Step 1: Select a 3 x 3 2-D window. Assume that the processing pixel is Pij, which lies at the center of window.

Step 2: If 0 < Pij< 255, then the processing pixel or Pij is uncorrupted and left unchanged.

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 Pij is replaced by the Salt noise(i.e. 255).
Case ii): If the selected window contains all the pixel value as255, then Pij is replaced by the pepper noise (i.e. 0).
Case iii): If the selected window contains all the value as 0 and 255 both. Then the processing pixel is replaced by my generated filter value of the window.
Case iv): If the selected window contain not all the element 0 and 255. Then eliminate 0 and 255 and find the median value of the remaining element. Replace Pij with median value.

Step 4: Repeat step 1 to 3 for the entire image until the process is complete.

ii. Modified Decision Base Unsymmetric Trimmed Median Filter (MDBUTMF)

In the Modified Decision Base Unsymmetric Trimmed Median filter (MDBUTMF) the pixels are checked to know whether they are noisy or noise free. If the processing pixel is 0 or 255 then it is considered as noisy and it is processed as per the algorithm given below.

Algorithm:

Step 1: Select 2-D window of size 3 x 3. Assume that the processing pixel as Pij which lies at the center of window.

Step 2: If 0 < Pij< 255, then Pij is an uncorrupted pixel and It is left unchanged.

Step 3: If Pij = 0 or Pij = 255 then it is corrupted pixel and two cases are possible as follow.

Case i): If the selected window contains all the elements as 0 and 255, then replace Pij with the my generated filter value of elements of the window.
Case ii): If the selected window contains not all the element as 0 and 255, then eliminate 0 and 255 and calculate median value of remaining element. Then replace Pij with the median value.

Step 4: Repeat steps 1 to 3 until the process is complete for the entire image.

The output obtained from MDBPTGMF or MDBUTMF is given to the second stage for further processing.

B. Stage-2 (Decision base Median Filter)

The Decision base Median Filter (DMF) works in the first stage of the proposed algorithm. At first a 3 x 3 window is selected. It decides whether the central pixel is corrupted or not. If it is an uncorrupted pixel, it remains unchanged and if corrupted it is replaced by the median value of the selected window. The algorithm for DMF is described as follows.

Algorithm:

Step 1: Select a 2-D window of size 3 x 3. The processing pixel is assumed as Pij which lies at the center of window.

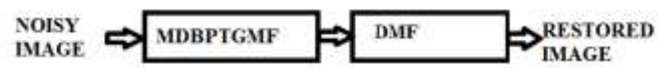
Step 2: If 0 < Pij< 255, then Pij is considered as uncorrupted pixel and is left unchanged.

Step 3: Otherwise, calculate the median of the pixels in the window and replace processing pixel by the median value.

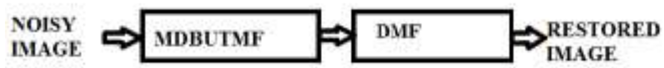
Step 4: Move the 3 x 3 window to the next pixel in the image. And repeat steps 1 to 3 until all the pixels in the entire image are processed.

C. Cascade Filter

The Decision base Median Filter (DMF) gives higher PSNR value,The MDBPTGMF and MDBUTMF gives lower PSNR value. MDBPTGMF and MDBUTMF are used to reduce the noise and the DMF is used to remove the noise completely as well as to enhance the image. In this structure MDBPTGMF or MDBUTMF is cascaded with DMF for the improvement of the output obtained from DMF. The noisy image is first given to stage-1.(i.e. either to MDBPTGMF or MDBUTMF). Then the output of the stage-1 is given as input of stage-2(i.e. to DMF). The proposed algorithm-1 (PA1) is the cascaded version of MDBPTGMF and DMF whereas proposed algorithm-2 is the cascaded version of MDBUTMF and DMF. The performance of PA2 is better than the performance of PA1. PA1 gives a better result at high noise density whereas PA2 is giving an excellent result for all noise level in terms of MAE, PSNR and IEF values as compared to other algorithms.



Cascade Filter-1 (PA1)



Cascade Filter-1 (PA2)

III. SIMULATION RESULTS

The proposed algorithms are tested using 512x512 8-bit/pixel image Leena.jpg. In the simulation, images are corrupted by Salt and Pepper noise. The noise level varies from 10% to 90% with increment of 10% and the performance is quantitatively measured by Mean Absolute Error (MAE), Peak Signal to Noise Ratio (PSNR) and Image Enhancement Factor (IEF).

$$MAE = \frac{\sum_{I,J}|Y(i,j) - Y'(i,j)|}{MXN} \quad (1)$$

$$\text{PSNR in dB} = \left(10log_{10}\frac{255^2}{MSE}\right) \quad (2)$$

$$\text{MSE}= \frac{\sum_I\sum_J(Y(i,j)-Y'(i-j))2}{M\times N} \quad (3)$$

$$\text{IEF}= \frac{\sum_I\sum_J(\eta(i-j)-Y(i,j))2}{\sum_I\sum_J(Y'(i-j)-Y(i,j))2} \quad (4)$$

where, MAE stands for Mean Absolute Error, MSE stands for Mean Square Error, PSNR stands for Peak Signal to Noise Ratio, IEF stands for Image Enhancement Factor. M X N is the size of the image, Y represents original image.

Table I : COMPARISON OF IEF VALUES FOR DIFFERENT ALOGITHMS OF LEENA IMAGE AT DIFFERENT NOISE DENSITIES.

Noise	IEF VALUES				
	MDBUTMF	**DBGTGMF**	**dmf**	**pa1**	**pa2**
0.0001	0.379	1.59	2.4	0.402	4.95
0.0002	0.854	3.14	2.89	1.12	6.41
0.0003	1.57	2.65	3.46	1.71	6.36
0.0004	1.74	3.72	2.75	2.6	5.8
0.0005	2.03	3.03	1.74	3.03	5.63
0.0006	2.54	3.05	0.894	3.23	4.66
0.0007	1.85	1.96	0.278	2.59	3.02
0.0008	0.695	0.739	0.112	0.848	0.734
0.0009	0.0737	0.124	0.0313	0.118	0.11

Table II : COMPARISON OF MAE VALUES FOR DIFFERENT ALOGITHMS OF LEENA IMAGE AT DIFFERENT NOISE DENSITIES.

Noise	MAE VALUES				
	MDBUTMF	**DBGTGMF**	**dmf**	**pa1**	**pa2**
0.1	0.0366	0.1	0.0366	0.1	0.0366
0.2	0.0569	0.2	0.0569	0.2	0.0569
0.3	0.0428	0.3	0.0428	0.3	0.0428
0.4	0.0648	0.4	0.0648	0.4	0.0648
0.5	0.0734	0.5	0.0734	0.5	0.0734
0.6	0.0831	0.6	0.0831	0.6	0.0831
0.7	0.127	0.7	0.127	0.7	0.127
0.8	0.243	0.8	0.243	0.8	0.243
0.9	0.09	0.9	0.09	0.9	0.09

Table III : COMPARISON OF PSNR in db FOR DIFFERENT ALOGITHMS OF LEENA IMAGE AT DIFFERENT NOISE DENSITIES.

Noise	PSNR in db				
	MDBUTMF	**DBGTGMF**	**dmf**	**pa1**	**pa2**
0.1	40.3279	46.4321	48.1499	40.6684	51.3338
0.2	38.1911	43.9347	43.5981	39.4637	47.0881
0.3	37.6082	39.8832	41.1039	37.726	43.6686
0.4	35.6492	38.9479	37.7133	37.2819	40.8986
0.5	34.3444	36.1972	33.6097	35.995	38.7635
0.6	33.6936	34.4877	29.2631	34.8015	36.4662
0.7	31.1596	31.3415	22.7824	32.4703	33.2243
0.8	25.5907	25.966	17.77	26.597	25.9902

			75	2	
0.9	15.0241	17.1986	11.16 29	17.080 7	16.6225

Table IV : COMPARISON OF MSE VALUES FOR DIFFERENT ALOGITHMS OF LEENA IMAGE AT DIFFERENT NOISE DENSITIES.

Nois e	MSE VALUE S				
	MDBUT MF	**DBGTG MF**	**dmf**	**pa1**	**pa2**
0.00 00	0.0024	0.0006	0.00 04	0.0022	0.0006
0.00 00	0.004	0.0011	0.00 11	0.003	0.0011
0.00 00	0.0046	0.0027	0.00 2	0.0044	0.0027
0.00 00	0.0071	0.0033	0.00 44	0.0049	0.0033
0.00 01	0.0112	0.0063	0.01 14	0.0066	0.0063
0.00 01	0.0201	0.0093	0.03 11	0.0087	0.0093
0.00 01	0.0724	0.0192	0.13 8	0.0148	0.0192
0.00 01	0.824	0.0664	0.43 7	0.0574	0.0664
0.00 01	0.0096	0.5	2.01	0.513	0.5

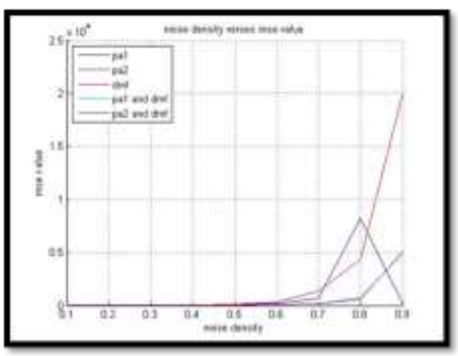


Fig.1: IEF at different noise densities

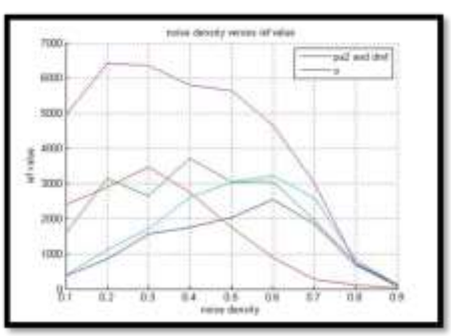


Fig.2: IEF at different noise densities

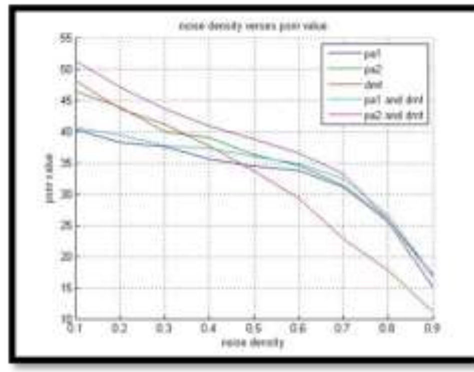


Fig.3: PSNR at different noise densities

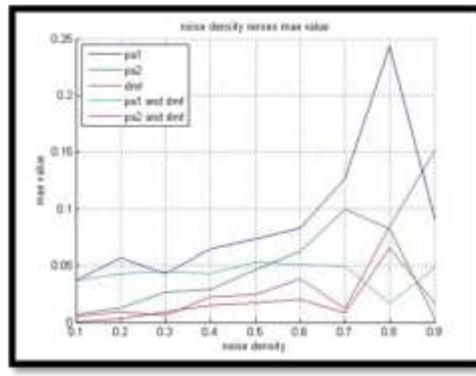
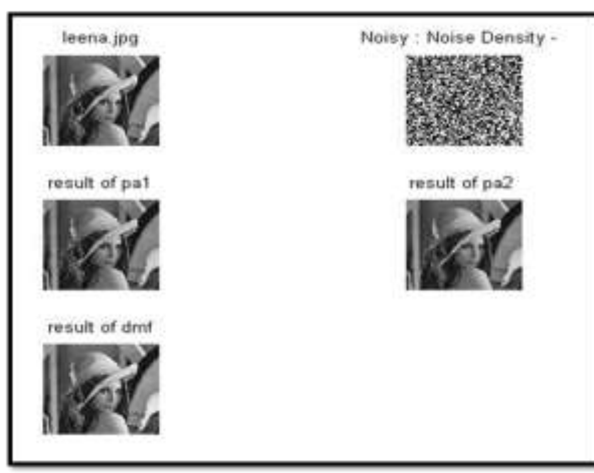


Fig. 4 : MAE at different noise densities

From Fig.1 to 4, it is clear that the proposed algorithm PA2 has better performance than other algorithm at medium and high noise level whereas PA1 has better performance at all noise level. In Fig 5 and 6, the original, noisy Leena and bgray images are shown and also the reconstructed Leena and bgray images obtained by various filters are given which clearly shows that our proposed methods are better than the other existing algorithm.

Fig. 5: Results of bgray image



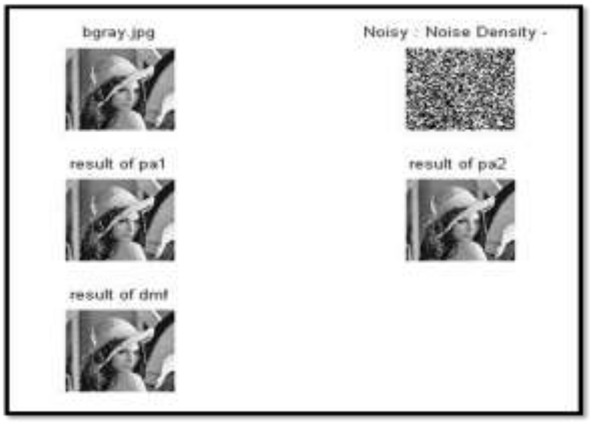


Fig. 6: Results of leena image

IV CONCLUSION

In this paper, it can be observed that the proposed filters give better result as compared to the existing algorithms in terms of MAE, PSNR and IEF. The proposed algorithms show excellent denoising capability and also preserve texture detail and edges effectively even at very high noise density. The proposed algorithms are effective for removal of salt and pepper noise at low, medium and high noise densities.

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