Detail Preserving Median Filter for High Density Impulse Noise

Kiran P.Dange
Department of ETC, V.E.Society's Institute of Technology, Chembur, Mumbai, India

R K Kulkarni
Department of ETC, V.E.Society's Institute of Technology, Chembur, Mumbai, India

ABSTRACT
For removing impulse noise, basic median filter is used. The median filters are not able to retain edges and fine details of images at high density noise. A new algorithm is proposed to overcome the limitations of existing methods. This algorithm is categorized into two stages. First stage is detection of impulse pixel depends on threshold values and second stage is filtering of corrupted pixels which are replaced by the median of uncorrupted pixels in the filtering window. This proposed algorithm works good up to 90% noise density. Extensive simulations show that the proposed filter restores fairly well even the images that are highly corrupted. The performance measures like PSNR, MSE, and UQI are better than other methods.

Keywords
Impulse noise, Threshold, Median filter

1. INTRODUCTION
Impulse noise 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 salt-and pepper and random-valued noise. Filtering is categorized into linear and nonlinear filter. Linear filter could produce very high blurring effect. The nonlinear filters have been utilized because of improved performance of removal of impulse noise and preserving edge details. The most widely used nonlinear filter is standard median(SM)filter[1] which is having tendency to sort the image pixels in descending order and find the median.This median replaces the noisy pixel. But the disadvantage of standard median filter is that it does not preserve image details and fine image details. The centre weighted and weighted median filter are improved version of median filter. The centre weighted median filter (CWM) [2] which provides weights to the centre pixel for the filtering process. The weighted median (WM) filtering [3] provides weights to control the filtering process which preserves image details. In order to avoid the influence of the noisy pixels on the filtered image, it is necessary to perform the impulse detection before filtering. The progressive switching median filter (PSMF) [5] is the filter of this category which achieves the detection and removal of impulse noise in two separate stages. In multi-state median (MSM) filter [6], the out-put of the filter is adaptively switched among those of a set of CWM filters having different center weights. The tri-state median filter [7] is a modified switching median filter that is obtained by including a center weighted median filter into a basic switching median filter structure.

The paper is organized as follows. Section 2 discusses the noisy model, section 3 explains the proposed algorithm, the simulation results in section 4 and section 5 is the conclusion.

2. IMPULSE NOISE MODEL
Noise is modeled as salt-and-pepper impulse noise. Pixels are randomly corrupted by two fixed external values, 0 and 255 (for 8-bit monochrome image), generated with the same probability. That is, for each image pixel at location (i, j) with intensity value S(i, j), the corresponding pixel of the noisy image will be x(i,j) , in which the probability density function of x(i,j) is

$$f(x) = \begin{cases} p/2, & \text{for } x=0 \\ 1-p, & \text{for } x=s(i,j) \\ p/2, & \text{for } x=255 \end{cases} \quad (1)$$

where p is the noise density.

3. PROPOSED ALGORITHM
This algorithm is divided into two stages In first stage, the detection of impulse noise is provided which detection of impulse pixel is depends upon the threshold values.And in second stage, the corrupted pixels is replaced by the median value of uncorrupted pixel in the filtering window.After analyzing the entire image, a two-dimensional binary decision map is formed at the end of the noise detection stage, with "0s" indicating the positions of "uncorrupted" pixels, and "1s" for those "corrupted" ones. The algorithm for impulse noise detection is as follows:

Let x be the noisy image of size m×n.

The algorithm for impulse noise detection and filtering is as follows:-

Step1:- Assume that current pixel under process is

X(i,j), apply the sliding window of size (2L+1)×(2L+1)

centered at X_{ij}

Step2:-Apply 3×3 window size for detection of noise

initially.

Step3:-Find the absolute difference (AD) between the centre pixel and neighboring pixels in the corresponding window.

Step4:-Find the number of pixels whose absolute difference lies between zero to particular threshold ($0 < AD \leq T$).For optimum performance T is selected as 25.

$$\zeta_{ij} = \sum_{-L \leq u, v \leq L} \delta_{i-u,j-v} \quad (2)$$

ζ_{ij} indicates that the number of pixels, which are similar to that of centre pixel

Step5:-Let as assume Ψ_{ij} is same size of the filtering window and assigned to one when ζij greater than a threshold T_2 .

$$\Psi_{ij} = \begin{cases} 1, & \text{for } \zeta_{ij} \geq T_2 \\ 0, & \text{otherwise} \end{cases} \quad (3)$$

Where T_2 is chosen as 4 for optimum performance.

Step 6:- Differentiation of noisy and noise free is be done by using following step

$$X_{*}\Psi = \begin{cases} 1, & \Psi_{ij} = 1 \\ 0, & \text{otherwise} \end{cases} \quad (4)$$

Where 1 indicates as noisy and o indicates as noise free pixels.

Step7:-By applying a filtering window of initial size 3×3 (for low density noise) to the noisy pixels which has zero value in the matrix (X* Ψ) and the replacement noisy pixel with median value of the uncorrupted pixel in the window.

Step8:-Apply 5×5 window size for medium density noise and for high density noise apply 7×7 window size.

4. RESULTS

The simulation is carried on different test images(Lena, Boat) in mat lab 7.0.The proposed method (PM)tested for test images Lena and boat of size 512× 512,8 bits per pixel gray scale images. The performance is measured using the parameters like Peak-Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE), and Universal Quality Index (UQI). They are defined by the following formula, The PSNR, MSE and UQI are tabulated in table no.1,table no.2 and table no.3 respectively.

$$PSNR = 10 \log_{10} (255^2/MSE) \quad (5)$$

$$MSE = 1/(M\times N) \sum_{ij} (f_{ij} - g_{ij})^2 \quad (6)$$

The universal quality index[8] is indicated by **Q**

$$Q = \frac{\rho_{fg}}{\rho_f + \rho_g} \cdot \frac{2 f' g'}{(f')^2+(g')^2} \cdot \frac{2\rho_f + 2\rho_g}{\rho^2_f + \rho^2_g} \quad (7)$$

Where f_{ij} and g_{ij} denote the original and output image.

(a)

(b)

(c)

(d)

(e)

(d)

Figure 1. (a) Original Lena.jpg (512×512 size) (b) Noisy image(60% noise density). Outputs of (c) SMF (d) WMF (e) PSMF (f)) Proposed method

Table 1. Comparison table of **PSNR** for different filter for Lena.jpg of size 512×512

Types of Filter	Noise Density 40%	50%	60%	70%	80%
SMF	19.03	15.45	12.44	10.09	8.19
CWMF	16.19	13.12	10.59	9.12	7.64
PSMF	25.88	21.19	12.46	10.01	8.23
Proposed method	25.25	24.83	24.18	22.90	19.98

Table 2. Comparison table of **MSE** for different filter For Lena.jpg of size 512×512

Types of Filter	Noise Density 40%	50%	60%	70%	80%
SMF	305.20	677.0	1330.0	2241.0	3464.5
CWMF	561.69	1101.	1882.	3028.	3913.7
PSMF	143.04	449.2	1350.9	6663.1	10275.0

Proposed method	193.88	213.7	248.2	332.8	651.88

The performance measures like PSNR, MSE and UQI are shown in table 1,2 and 3.The comparision with different filters shows that the at high density PSNR and UQI are showing very less,but the proposed method(PM) filter shows that the better PSNR and UQI even at high density.Whereas MSE is very high for above showing filter in the table 2,but this proposed filter shows less MSE for high noise density.

Table 3. Comparison table of **UQI** for different filter for Lena.jpg of size 512×512

Types of Filter	Noise Density 40%	50%	60%	70%	80%
SMF	0.9853	0.9495	0.8275	0.6195	0.3695
CWMF	0.8456	0.6835	0.4941	0.3164	0.1762
PSMF	0.9696	0.9142	0.5511	0.3718	0.2362
Proposed method	0.9589	0.9547	0.9475	0.9302	0.8668

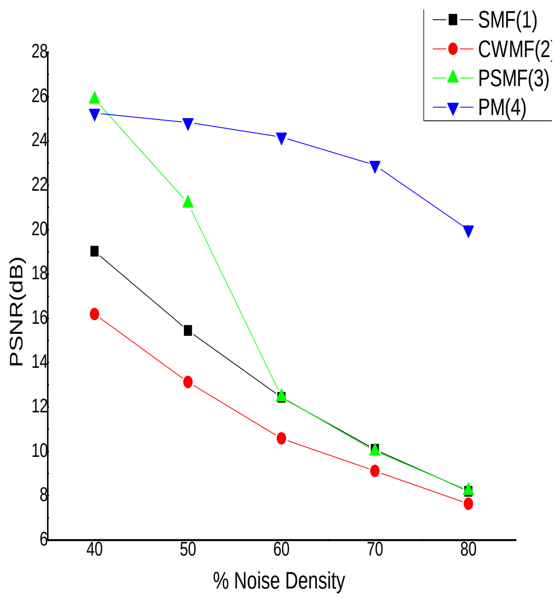

FIGURE 3.GRAPHICAL REPRESENTATION OF PSNR

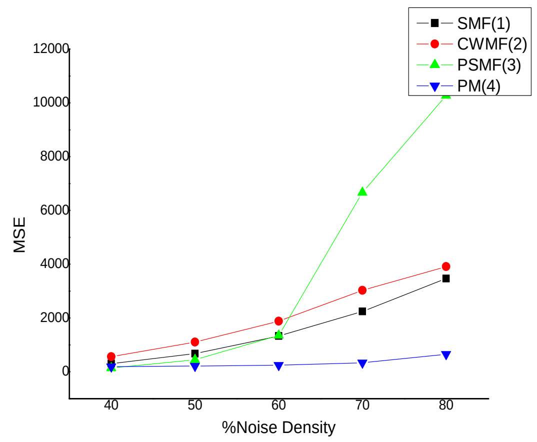

Figure 4.Graphical representation of MSE

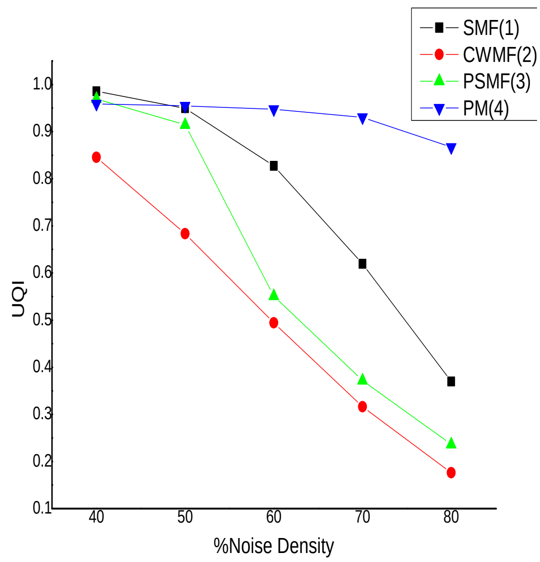

Figure 5.Graphical representation of UQI

(b) (a)

Figure 6.(a) Lena image corrupted by 80% noise density

(b) Filtered image by Proposed Method

The visual quality shows that the proposed method's performance is best when compared to other filters. Fig. 3,4 and 5 respectively shows graphical comparison of the PSNR, MSE and UQI parameter. From visual quality, comparison tables and graphs, the proposed filter produce better result compared to other existing methods. Fig.6 shows that the proposed algorithm removes very high density impulse noise for gray scale.

5. CONCLUSION

As window size increases, the blurring effect occurs in other filtering methods, but the proposed filter method reduces blurring effect for window size 7x7 for filtering process. The proposed filtering method also shows effective filtering for noise density varying from 10% to 80%.

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