

# Reduction of High Density Impulse Noise Using Block Based Decision and Unsymmetric Trimmed Median Filter

Shivpratap Pandey, Rupali Kushwaha, Anamika

**Abstract**— Digital images could be contaminated by impulse noise during image acquisition or transmission. The intensity of impulse noise has the tendency of being either relatively high or relatively low. Thus, it could severely degrade the image quality and cause some loss of information details. A new proposed algorithm modified decision based unsymmetric trimmed median filter (MDBUTMF) for the restoration of gray scale images that are highly corrupted by salt and pepper noise is used. This algorithm shows better results than the Standard Median Filter (MF), Adaptive median filter (AMF), Decision Based Unsymmetric Trimmed adaptive median filter (DBUTAMF), and Progressive Switched Median Filter (PSMF) at high noise density. The proposed algorithm is tested against different gray scale images and it gives better Peak Signal-to-Noise Ratio (PSNR).

**Index Terms**— Adaptive, Impulse Noise, MATLAB, Median filter, PSMF, PSNR, Unsymmetric Trimmed Median Filter.

## 1 INTRODUCTION

Impulse noise in images is present due to bit errors in transmission or introduced during the signal acquisition stage. There are two types of impulse noise, they are salt and pepper noise and random valued noise[1]. Salt and pepper noise can corrupt the images where the corrupted pixel takes either maximum or minimum gray level. Several nonlinear filters have been proposed for restoration of images contaminated by salt and pepper noise[2].

There are various methods to help restore an image from impulse Noise. The median filter was once the most popular nonlinear filter for removing salt & pepper noise because of its good denoising power and computational efficiency [3]. However, when the noise level is over 50%, some details and edges of the original image are smeared by the filter.

In switching median filter [4], [5] the decision is based on a pre-defined threshold value. The use of a switching scheme in impulse removal has attracted more attention because it can avoid the damage of good pixels by employing an impulse detector to determine which pixels should be filtered [6]–[10]. The major drawback of this method is that defining a robust decision is difficult.

In order to avoid this drawback, Decision Based Unsymmetric Trimmed Median Filter (MDBUTAMF) is proposed [11]. This algorithm does not give better results at very high noise density that is at 80% to 90%. These filters had some drawbacks when the density of the impulse noise in the image is high:

- Signal weakening (objects corners and edges blurred).
- Affecting non-corrupted (good) image pixels when the density of the noise is high.
- Difficult to detect and preserve edge details.
- Lead to blurring the image at high noise density.

The proposed Modified Decision Based Un-symmetric Trimmed Median Filter (MDBUTMF) algorithm removes these drawbacks at high noise density and gives better Peak Signal-to-Noise Ratio (PSNR). This algorithm is implemented in MATLAB and tested on some standard images.

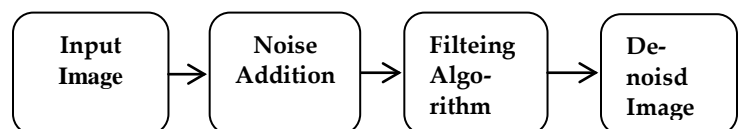


Fig.1 Block diagram for removing the noise from Noisy image

## 2 METHODOLOGY

### 2.1 DESCRIPTIONS ABOUT MODIFIED DECISION BASED UNSYMMETRIC TRIMMED ADAPTIVE MEDIAN FILTER (MDBUTAMF):

The Modified Decision Based Unsymmetrical Trimmed Adaptive Median Filter (DBUTAMF) algorithm processes the corrupted images by first detecting the salt and pepper noise. The processing pixel is checked whether it is noisy or noise free. If the processing pixel lies between maximum and minimum gray level values, then it is noise-free pixel and it is left unchanged. If the processing pixel takes the maximum or min-

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imum gray level, then it is noisy pixel which is processed by DBUTAMF.

**-The steps of the MDBUTAMF Algorithm are elucidated as follows:**

**Step 1:** Read Noisy Image.

**Step 2:** Select 2D window of size 3x3 with centre element as processing pixel. Assume that the pixel being processed is  $P_{ij}$ .

**Step 3:** If  $P_{ij}$  is an uncorrupted pixel (that is,  $0 < P_{ij} < 255$ ), then its value is left unchanged.

**Step 4:** If  $P_{ij} = 0$  or  $P_{ij} = 255$ , then  $P_{ij}$  is a corrupted pixel.

**Step 5:** If 3/4th or more pixels in selected window are noisy then increase window size to 5x5.

**Step 6:** If all the elements in the selected window are 0's and 255's, then replace  $P_{ij}$  with the mean of the elements in the window else go to step 6.

**Step 7:** Eliminate 0's and 255's from the selected window and find the median value of the remaining elements. Replace  $P_{ij}$  with the median value.

**Step 8:** Repeat steps 2 to 6 until all the pixels in the entire image are processed.

**-The detailed description of the MDBUTAMF algorithm:**

Each and every pixel of an image is checked for the presence of salt and pepper noise. Different cases are illustrated.

**Case i)** If processing pixel in the selected 3x3 window is non-noisy pixel, it does not require further processing. For example, if processing pixel is **99**, then it is non-noisy pixel:

73	50	175
211	<b>99</b>	114
91	39	56

**Case ii)** If all the pixel values in the selected window contains salt or pepper noise (i.e., 255 or 0 pixel value):

0	0	255	0	255
255	255	0	255	0
0	0	0	255	255
0	0	255	255	0
255	0	0	255	255

where "0" is processing pixel, i.e.,  $P_{ij}$ .

Since all the elements surrounding are 0's and 255's, if one takes the median value it will be either 0 or 255 which is again noisy. To solve this problem, the mean of the selected window is found and the processing pixel  $P_{ij}$  is replaced by the mean value. Here the mean value is 122.4. Hence replace the processing pixel  $P_{ij}$  by 122.4.

**Case iii)** If 3/4th or more pixels in the selected 3x3 window including processing pixel are noisy (i.e., 255 or 0 pixel):

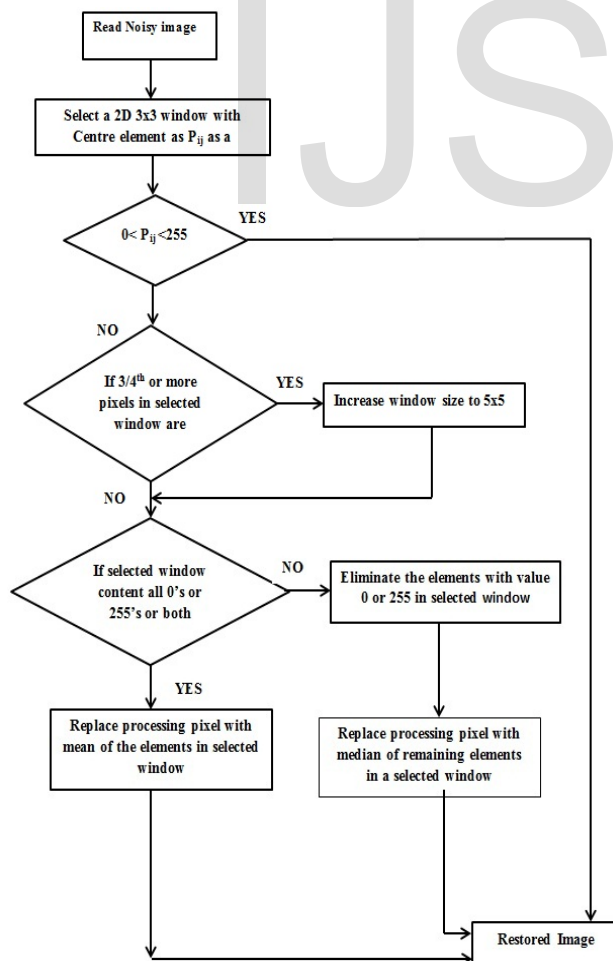


Fig.2 Flow Chart of MDBUTAMF

0	0	255
255	255	0
0	255	93

As more than 3/4th pixels in the selected 3x3 window are noisy, select 5x5 windows.

99	113	0	0	255
255	0	0	255	165
190	255	255	0	0
0	0	255	93	255
56	255	77	0	255

Now eliminate the salt and pepper noise from the selected 5x5 window. The 1D array of the above matrix is

[99 113 0 0 255 255 0 0 255 165 190 255 255 0 0 0 255 93 255 56 255 77 0 255]

After elimination of 0's and 255's, the pixel values in the selected window will be

[ 56 77 93 99 113 165 190]

Here the median value is 99. Hence replace the processing pixel  $P_{ij}$  by 99.

**Case iv)** If less than 3/4th pixels in the selected window including processing pixel are noisy (i.e., 255 or 0 pixel value):

0	78	255
255	0	0
75	255	80

Now eliminate the salt and pepper noise from the selected 3x3 window. The 1D array of the above matrix is

[0 78 255 255 0 0 75 255 80]

After elimination of 0's and 255's, the pixel values in the selected window will be [78 75 80]. Here the median value is 78. Hence replace the processing pixel  $P_{ij}$  by 78.

## 2.2 DESCRIPTION ABOUT PROPOSED ALGORITHM MODIFIED DECISION BASED UNSYMMETRIC TRIMMED MEDIAN FILTER (MDBUTMF)

The proposed Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF) algorithm processes the corrupted images by first detecting the impulse noise. The processing pixel is checked whether it is noisy or noisy free. That is, if the processing pixel lies between maximum and minimum gray level values then it is noise free pixel, it is left unchanged. If the processing pixel takes the maximum or minimum gray level then it is noisy pixel which is processed by MDBUTMF.

- **The step of the MDBUTMF Algorithm is elucidated as follows:**

**Step 1:** Images are processed. Select a 2-D window of size 3x3. Assume that the pixel being processed is  $P_{ij}$ .

**Step 2:** If  $0 < P_{ij} < 255$  then  $P_{ij}$  is an uncorrupted pixel.

**Step3:** If  $P_{ij} = 0$  or  $P_{ij} = 255$  then is a corrupted pixel then two cases are possible as given in Case i) and ii).

**Case i)** If the selected windows contain all the elements as 0's and 255's. Then replace  $P_{ij}$  with the mean of the element of window.

**Case ii)** If the selected window contains not all elements as 0's and 255's. The eliminate 255's and 0's and find the median value of the remaining elements. Replace  $P_{ij}$  with the median value.

**Step 4:** Repeat steps 1 to 3 until all the pixels in the entire image are processed.

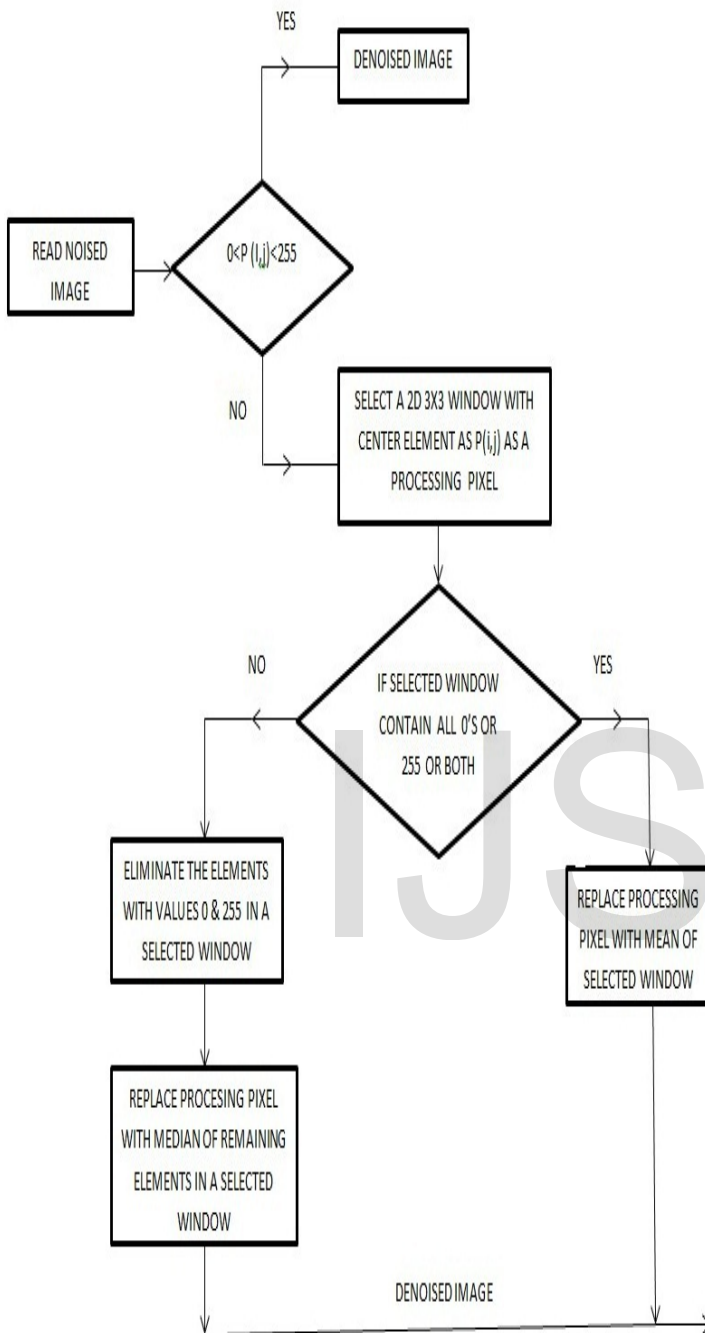


Fig.3 Flow chart of MDBUTMF

**The detailed description of the MDBUTMF algorithm:**

Each and every pixel of the image is checked for the presence of salt and pepper noise. If the processing pixel is noisy and all other pixel values are either 0's or 255's is illustrated in Case ( i). If the processing pixel is noisy pixel that is 0 or 255 is illustrated in Case (ii). If the processing pixel is not noisy pixel and its value lies between 0 and 255 is illustrated in Case ( iii).

**Case i):** If the selected window contains salt/pepper noise as processing pixel (i.e., 255/0 pixel value) and neighboring pixel values contains all pixels that adds salt and pepper noise to the image:

$$\begin{bmatrix} 0 & 255 & 0 \\ 0 & (255) & 255 \\ 255 & 0 & 255 \end{bmatrix}$$

Where "255" is processing pixel, i.e.,  $P_{ij}$ .

Mean value (average value):

$$(0+255+0+0+255+255+255+0+255)/9 = 141.66$$

Since all the elements surrounding  $P_{ij}$  are 0's and 255's. If one takes the median value it will be both 0 and 255 which is again noisy. To solve this problem, the mean of the selected window is found and the processing pixel is replaced by the mean value. Here the mean value is 141.66. Replace the processing pixel by 141.66.

**Case ii):** If the selected window contains salt or pepper noise as processing pixel (i.e., 255/0 pixel value) and neighboring pixel values contains some pixels that adds salt (i.e., 255 pixel value) and pepper noise to the image.

$$\begin{bmatrix} 78 & 90 & 0 \\ 120 & (0) & 255 \\ 97 & 255 & 73 \end{bmatrix}$$

where "0" is processing pixel, i.e.,  $P_{ij}$ .

Now eliminate the salt and pepper noise from the selected window. That is, elimination of 0's and 255's. The 1-D array of the above matrix is.

$$[78 \ 90 \ 0 \ 120 \ 0 \ 255 \ 97 \ 255 \ 73]$$

After elimination of 0's and 255's the pixel values in the selected window will be

$$[73 \ 78 \ 90 \ 97 \ 120]$$

Here the median value is 90. Hence replace the processing pixel  $P_{ij}$  by 90.

**Case iii):** If the selected window contains a noise free pixel as a processing pixel, it does not require further processing. For example, if the processing pixel is 90 then it is noise free pixel:

$$\begin{bmatrix} 43 & 67 & 70 \\ 55 & (90) & 79 \\ 85 & 81 & 66 \end{bmatrix}$$

where "90" is processing pixel, i.e.,  $P_{ij}$ . Since "90" is a noise free pixel it does not require further processing.

### 3. RESULT AND DISCUSSION

Performances of algorithms are measured by calculating Following parameters:

**MSE:** MSE measures the average of the squares of the "errors." The error is the amount by which the value implied by the estimator differs from the quantity to be estimate.

$$MSE = \frac{1}{M \times N} (\sum_i \sum_j (Y(i,j) - \hat{Y}(i,j))^2) \tag{1}$$

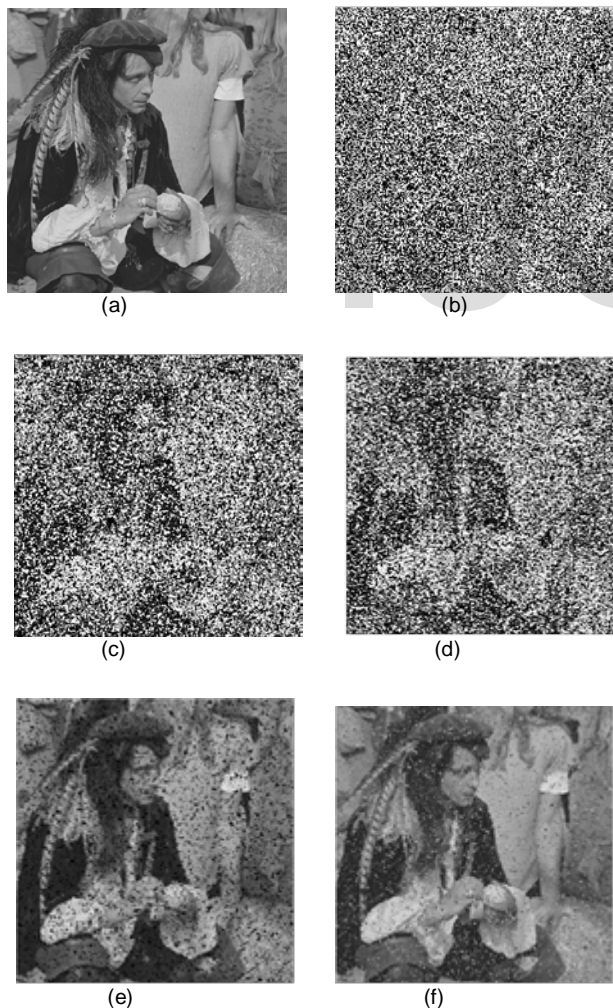
Where  $M \times N$  is size of the image,  $Y$  represents the original image,  $\hat{Y}$  represents the denoised image.

**PSNR:** Peak signal-to-noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation

$$PSNR \text{ in dB} = 10 \cdot \log_{10} (255^2 / MSE) \tag{2}$$

**Table 1. Estimated values of PSNR from different filters for 'LENA' (256×256) gray scale image:**

% NOISE	MF	PSMF	MDBUTAMF	PROPOSED
10	27.39	30.79	32.17	31.52
20	26.32	28.24	29.22	28.93
30	24.26	25.33	27.18	27.26
40	21.77	22.65	25.28	25.76
50	18.32	19.19	24	24.59
60	16.14	12.13	21.67	23.30
70	14	9.86	18.11	21.31
80	11.97	8.07	13.80	18.77
90	10.42	8.67	9.46	15.32

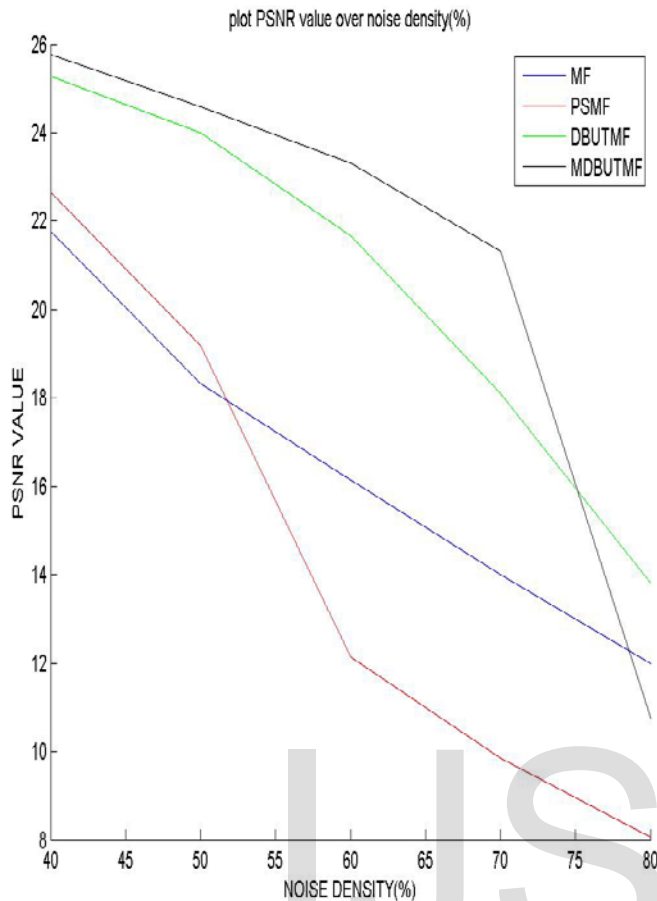


**Table 2. Comparison of estimated values of PSNR of different gray scale images (256×256) at a noise level of 80%:**

- LENA
- CAMERAMAN
- PIRATE

IMAGE	MF	PSMF	MDBUTAMF	PROPOSED
LENA	11.97	8.07	13.80	18.77
CAMERAMAN	12.16	7.54	13.34	17.11
PIRATE	13.38	8.05	14.82	14.07

Fig.5 a) Original image, b) Corrupted image by 80% Impulse Noise, c) Median filter, d) PSM filter, e) MDBUTAM filter f) MDBUTM filter



**Figure.6 Plot PSNR Value of different filter over different noise density (%)**

In our experiment ,we introduced fixed amount of impulse noise in to original image 'Lena'. Fig(5) ,show that our proposed filter has better restoration particularly for highly corrupted image i.e. noise ration larger than 90% compared to MF, PSMF, MDBUTAMF and MDBUTMF

#### 4. CONCLUSION

MDBUTMF algorithm is gives better performance in comparison with MF, AMF and other existing noise removal algorithms in terms of PSNR. The performance of the algorithm has been tested at low, medium and high noise densities on gray-scale images. Even at high noise density levels the MDBUTMF gives better results in comparison with other existing algorithms. Both visual and quantitative results are demonstrated. The proposed algorithm is effective for salt and pepper noise removal in images at high noise densities.

#### 5. ACKNOWLEDGEMENT

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