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# REMOVAL OF HIGH DENSITY IMPULSE NOISE THROUGH MODIFIED NON-LINEAR FILTER

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**ABSTRACT**

A New algorithm for the restoration of gray scale and color images are highly corrupted by impulse noise (salt and pepper noise) is proposed in this paper. This proposed algorithm shows better results than the Standard Median Filter (SMF), Decision Based Median Filter (DBMF), Modified Decision Based Median Filter (MDBMF), Progressive Switched Median Filter (PSMF) and Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF). The proposed algorithm replaces the noisy pixel by trimmed median value when other pixel values, 0's and 255's are present in the selected window and when all the pixel values are 0's and 255's then the noise pixel is replaced by increasing window size and finding trimmed mean based on algorithm. Different grayscale and color images are tested by using the proposed algorithm and found to produce better Peak Signal to Noise Ratio (PSNR) and Image Enhancement Factor (IEF)

**Keywords:** *Image Enhancement Factor, Trimmed Median, Trimmed Mean, Restoration, Peak Signal To Noise Ratio.*

## 1. INTRODUCTION

Images often corrupted by various noises during the process of generation and transmission. Mostly Images are corrupted by impulse noise. There are two types of impulses noise, they are salt and pepper noise [1] and random valued noise. The salt and pepper noise corrupted pixels of image take either maximum or minimum pixel value. In this paper we deal with removal of salt and pepper noise from corrupted images. Removal of salt and pepper noise is done by two stages: detection of noisy pixel and replacement of that pixel. Several filters have been proposed for recovering images corrupted by salt and pepper noise. Among these standard median filter is reliable and easy to implement. However, the major drawback of Median filter (MF) is that it works effectively only at low noise densities [2]. At high noise densities image cannot be recovered and edge details of original image are not preserved. Adaptive Median Filter (AMF) [2] yields better results than median filter at low noise densities. But at high noise densities the window size has to be increases which may lead to image blurring. Next switching median filter [4], [5] uses pre-defined threshold value for recovering corrupted image. The major drawback of this method is defining threshold value. Also these method yields unsatisfactory results in preserving edge details at high noise densities.

To overcome the above drawback of these filters, Decision Based Algorithm (DBA) is proposed [6]. In this algorithm pixel is processed only when its value is either 0 or 255 or else left unchanged. Even these method uses median as its tool. But in case the output of median will be 0 or 255 which is noisy. In such case, neighboring pixel is used for replacement. Another algorithm was found where instead of just replacing corrupted pixel with neighborhood pixel value it is replaced with mean of neighborhood pixels [7]. But both fail in recovering image at high noise densities. In order to avoid there drawbacks, Decision Based un-symmetric Trimmed Median Filter (DBUTMF) is

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proposed [8]. But at high noise densities, if selected window contains all 0's and 255's or both then, trimmed median cannot be found. To overcome above drawback Modified Decision Based Un-symmetric Trimmed Median Filter (MDBUTMF) is proposed [9]. It yields better results than all previous algorithms at high noise densities. The proposed Modified Non-linear filter yields better results at very high noise density that is at 80% and 90% and gives better Peak Signal-to-Noise Ratio (PSNR) and Image Enhancement Factor (IEF) values than the MDBUTMF and existing algorithms.

The rest of the paper is structured as follows; a brief introduction of un-symmetric trimmed median and mean filters is given in Section II. Section III describes about the proposed algorithm and different cases of proposed algorithm. The detailed description of the proposed algorithm with an example is presented in Section IV. Section V contains simulation results with different images. Finally conclusions are drawn in Section VI.

## 2. UN-SYMMETRIC TRIMMED MEDIAN AND MEAN FILTERS

In this section we present the concept of trimmed median and mean filters. Conventionally, Alpha Trimmed Mean Filtering (ATMF) is_ symmetrical filter. As symmetric at either end even un-corrupted pixels are trimmed. This leads to loss of image details and blurring of the image. In order to overcome this drawback, an Un-symmetric Trimmed Median and Mean Filter are found. In this method, the selected 3 x 3 window elements which contain 0's or 255's or both are removed. Then the median or mean value of remaining pixels is taken. This median or mean value is replaced in corrupted pixel value.

## 3. PROPOSED ALGORITHM

The proposed Modified Non-linear Filter algorithm processes the corrupted images by first detecting the noisy pixels in the image. To check processing pixel is noisy or noise free by verifying whether it lies between maximum and minimum grey level values then it is noise free pixel, else pixel is said to be corrupted. Only corrupted pixels are processed to replace with noise free pixel value, uncorrupted pixels are left unchanged. The steps of Modified Non-linear filter are elucidated as follows.

ALGORITHM

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

Step 2: If $0 < P_{ij} < 255$ then $P_{ij}$ is an uncorrupted pixel and its value is left unchanged. This is illustrated in case iii) of Section IV.

Step 3: If $P_{ij} = 0$ or $P_{ij} = 255$ then $P_{ij}$ is_ corrupted pixel then two cases are possible as given in case 1) and 2).

Case 1): If the selected window contains not all elements as 0's and 255's. Then eliminate 0's and 255's from window and find the median of the remaining pixels. Replace $P_{ij}$ with the median value.

Case 2): If the selected window contains all the elements as 0's and 255's. Then it again draws few steps:

Step i: Increase the window size by two. Contains three cases

Case i): If increased window contains not all elements as 0's and 255's.Then eliminate 0's and 255's from window and find the mean of remaining pixels. Replace $P_{ij}$ with the mean value.

Case ii): If increased window contains all 0's and 255 and maximum window size limit not reached then follow step i.

Case iii): If increased window contains all 0's and 255 and maximum window limit has reached. Then find out mean of the elements in window and replace that value in $P_{ij.}$

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

The pictorial representation of each case of proposed algorithm is shown in Fig. 1.

The detailed description of each case of flowchart shown in Fig. 1 is illustrated through an example in section IV.

## 4. ILLUSRATION OF MNF ALGORITHM

Each and every pixel of the image is processed for checking salt and pepper noise. Different cases are illustrated in this section.

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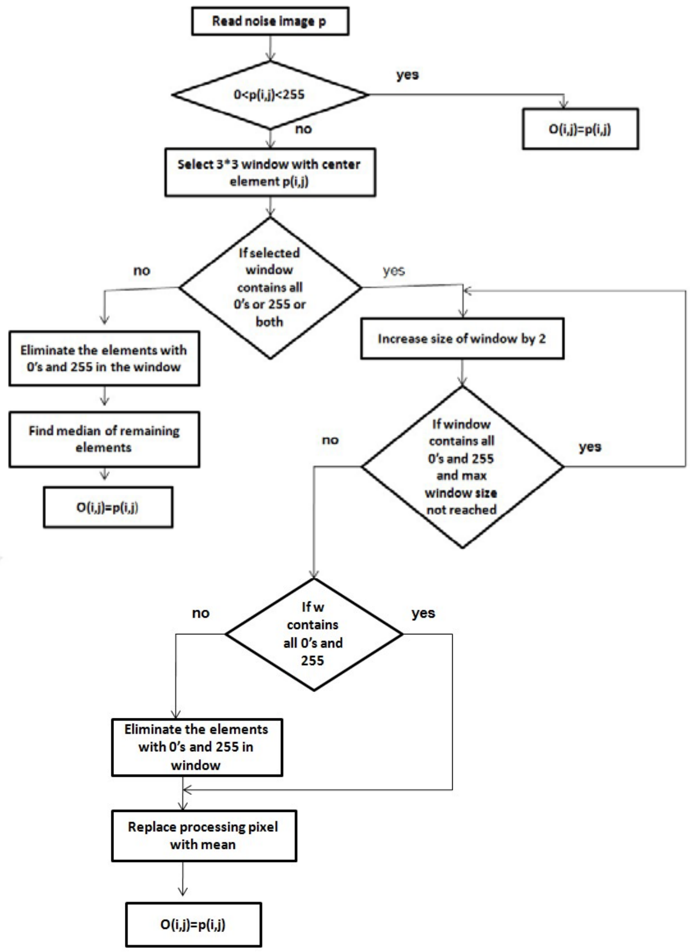


*Fig.1: Flow Chart Of MNF*

Case i): If the processing pixel is not noisy pixel contains all values in between minimum and maximum grey level values then processing pixel is not changed.

Case ii): If the processing pixel is noisy and even few neighbor pixels are noisy not all:

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

Where "0" is processing pixel. Now eliminate the corrupted pixels from window. That is eliminating 0's and 255's from window. Remaining pixels are [78 90 120 97 73]. Here median value is 90. Hence it is replaced with processing pixel.

Case iii): If the selected window contains processing pixel noisy and also all the window elements are 0's and 255's.

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

Then two steps are drawn

Step i): Increase the window size if maximum window limit has not reached. This again draws cases.

Case 1): After increasing if window not having all 0's and 255's.

$$\begin{bmatrix} 0 & 255 & 0 & 80 \\ 0 & 255 & 255 & 255 \\ 255 & 0 & 255 & 150 \\ 120 & 60 & 30 & 40 \end{bmatrix}$$

Then remove pixels with 0's and 255's and that results [80 150 120 60 30 40]. Find the mean of these pixels results 80. This is replaced in processing pixel.

Case 2): After increasing if window contains all 0's and 255 then follow step i.

Step ii): If maximum window size limit is reached and even then window has all 0's and 255's then find mean of all elements. Replace this value with processing pixel value.

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This is followed for each and every pixel in image.

## 5. SIMULATION RESULTS

The performance of proposed algorithm is tested for different grey scale and color images

*Table I: Comparison Of PSNR Values Of Different Algorithms For Lena Image At Different Noise Densities*

| Noise Density % | MF | AMF | PSMF | DBA | MDBA | MDBUTMF | New Approach |
|---|---|---|---|---|---|---|---|
| **10** | 28.4938 | 21.9845 | 30.6494 | 36.7565 | 36.7569 | 38.1290 | 37.3489 |
| **20** | 25.7542 | 21.9297 | 28.2089 | 33.2606 | 33.2607 | 34.6005 | 34.2358 |
| **30** | 21.8465 | 21.4735 | 25.5590 | 30.5659 | 30.5308 | 32.1427 | 32.1412 |
| **40** | 18.4076 | 21.4735 | 22.6909 | 28.2609 | 28.2981 | 32.0886 | 30.5796 |
| **50** | 14.7340 | 20.6542 | 19.4425 | 26.2846 | 26.2503 | 28.2175 | 29.0056 |
| **60** | 12.2348 | 18.4092 | 12.8511 | 24.5361 | 24.6321 | 26.5937 | 27.8240 |
| **70** | 9.9837 | 14.8564 | 10.5206 | 22.7798 | 22.9338 | 24.3859 | 26.0541 |
| **80** | 8.0229 | 11.2968 | 8.4849 | 20.1441 | 20.4098 | 22.0101 | 24.3291 |
| **90** | 6.5759 | 8.0603 | 6.7847 | 17.1205 | 17.2242 | 17.9865 | 21.3250 |

*Table II :Comparision Of Ief Values Of Different Algorithms For Lena Image At Different Noise Densities*

| Noise Density% | MF | AMF | PSMF | DBA | MDBA | MDBUTMF | New Approach |
|---|---|---|---|---|---|---|---|
| **10** | 20.5734 | 4.2759 | 33.1849 | 137.9069 | 137.9166 | 189.1606 | 158.0611 |
| **20** | 21.3987 | 8.9433 | 38.1071 | 120.5101 | 120.5152 | 164.0651 | 150.8512 |
| **30** | 13.1198 | 12.9477 | 30.6195 | 97.6947 | 96.9086 | 140.4587 | 140.4090 |
| **40** | 7.8805 | 16.0162 | 21.2920 | 76.1874 | 76.8418 | 116.0530 | 129.9442 |
| **50** | 4.2859 | 16.4574 | 12.5810 | 61.2490 | 60.7677 | 95.5859 | 114.6051 |
| **60** | 2.8533 | 11.8101 | 3.3133 | 48.4701 | 49.5535 | 77.8460 | 103.3410 |
| **70** | 1.9922 | 6.0858 | 2.2493 | 37.9277 | 39.2965 | 54.8988 | 80.6091 |
| **80** | 1.4589 | 3.0673 | 1.6051 | 23.7756 | 25.2756 | 36.5369 | 62.3204 |
| **90** | 1.1712 | 1.6499 | 1.2257 | 13.2768 | 13.5976 | 16.2066 | 34.9573 |

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Is varied from 10% to 90%. De-noising performances are quantitatively measured by the PSNR and IEF as defined in (1) and (3), respectively:

$$PSNR\ in\,dB = 10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (1)$$

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

$$IEF = \frac{\sum_i \sum_j (\eta(i,j) - Y(i,j))^2}{\sum_i \sum_j (\hat{Y}(i,j) - Y(i,j))^2} \quad (3)$$

Where MSE stands for mean square error, IEF stands for image enhancement factor, M x N is size of the image, Y represents the original image, $\hat{Y}$ denotes the de-noised image, and η represents the noisy image.

The PSNR and IEF values of the proposed algorithm are compared against the existing algorithms by varying the noise density from 10% to 90% and are shown in Table I and Table II. From the Tables I and II, it is observed that the performance of the proposed algorithm is better than the existing algorithms at both low and high noise densities.

A plot of PSNR and IEF against noise densities for Lena image is shown in Fig.2 and Fig. 3.

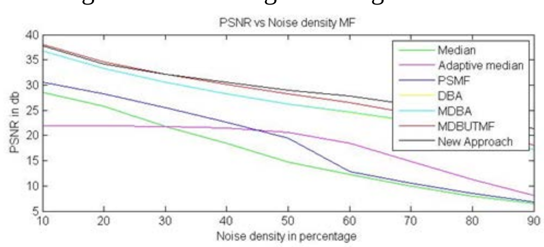


*Fig.2 PSNR DB Vs Noise Density %*

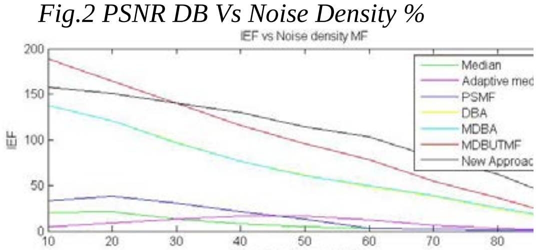


*Fig. 3: IEF DB Vs Noise Density %*

*Table 3: Comparison Of IEF Values Of Baboon*

| Noise Density% | MDBUTMF | New |
|---|---|---|
| **10** | 63.7114 | 67.6481 |
| **20** | 61.2560 | 65.8559 |
| **30** | 55.3882 | 62.1911 |
| **40** | 51.3934 | 58.8605 |
| **50** | 45.6078 | 53.7270 |
| **60** | 40.4391 | 48.5641 |
| **70** | 36.2320 | 44.9086 |
| **80** | 28.9281 | 37.4392 |
| **90** | 18.8394 | 28.6548 |

Table 3 represents the values of IEF of baboon for MDBUTMF and Proposed filter (MNF).

*Table 4: Comparison Of PSNR Values Of Baboon*

| Noise Density% | MDBUTMF | New Approach |
|---|---|---|
| **10** | 33.5954 | 33.8557 |
| **20** | 30.5159 | 30.8304 |
| **30** | 28.2890 | 28.7921 |
| **40** | 26.7305 | 27.3196 |
| **50** | 25.1829 | 25.8945 |
| **60** | 23.9281 | 24.7232 |
| **70** | 22.7632 | 23.6956 |
| **80** | 21.2044 | 22.3244 |
| **90** | 18.8296 | 20.6509 |

Table 4 represents the values of PSNR of cameraman for MDBUTMF and Proposed filter (MNF).

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The analysis of the proposed algorithm against all the existing algorithms at different noise densities for Lena image grey is shown in Fig. 4 and 5. In these images first row represents the processed image at 80% and second row represents processing of 90% corrupted images. Each and every column represents different algorithms processed images in order MF, AMF, PSMF, DBA, MDBA, MDBUTMF and MNF. The proposed image is tested for baboon and Lena. MNF yields better results compared to all the existing algorithms. Fig. 6 and 7 shows the processing of color images of different algorithms.

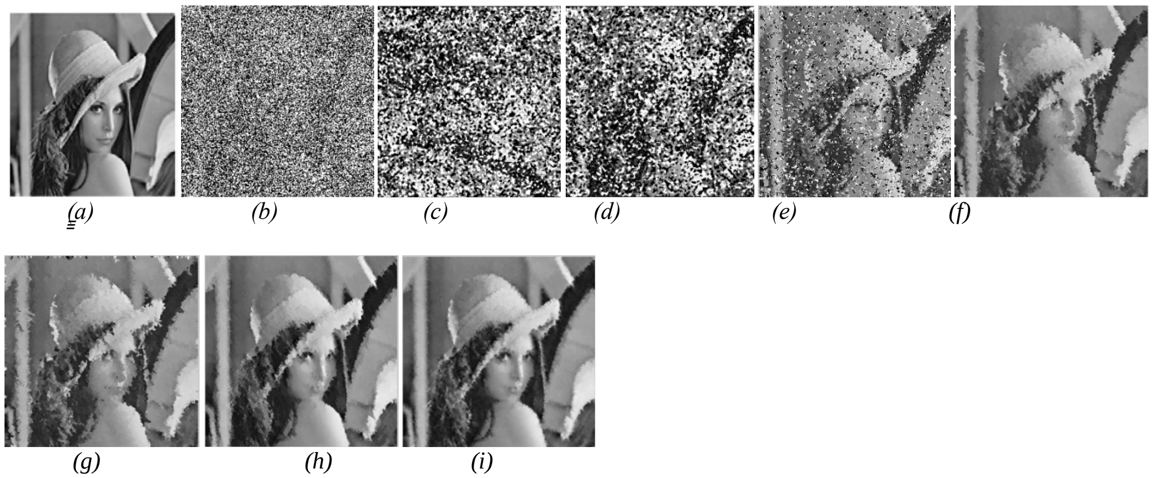


*Figure 4 Results for 80% noise corrupted lena image (a) Orginal image (b) Noise image (c) MF (d) AMF (e) PSMF (f) DBA (g) MDBA (h) MDBUTMF (i) MNF*

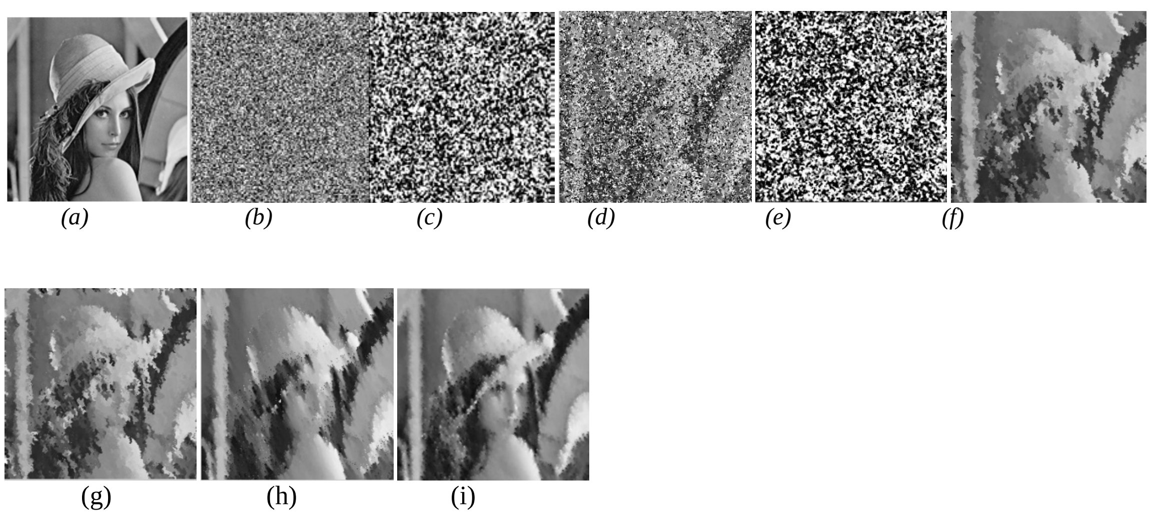


*Figure 5 Results for 90% noise corrupted lena image (a) Orginal image (b) Noise image (c) MF (d) AMF (e) PSMF (f) DBA (g) MDBA (h) MDBUTMF (i) MNF*

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*Figure 6 Results for 80% noise corrupted lena color image (a) Orginal image (b) Noise image (c) MF (d) AMF (e) PSMF (f) DBA (g) MDBA (h) MDBUTMF (i) MNF*

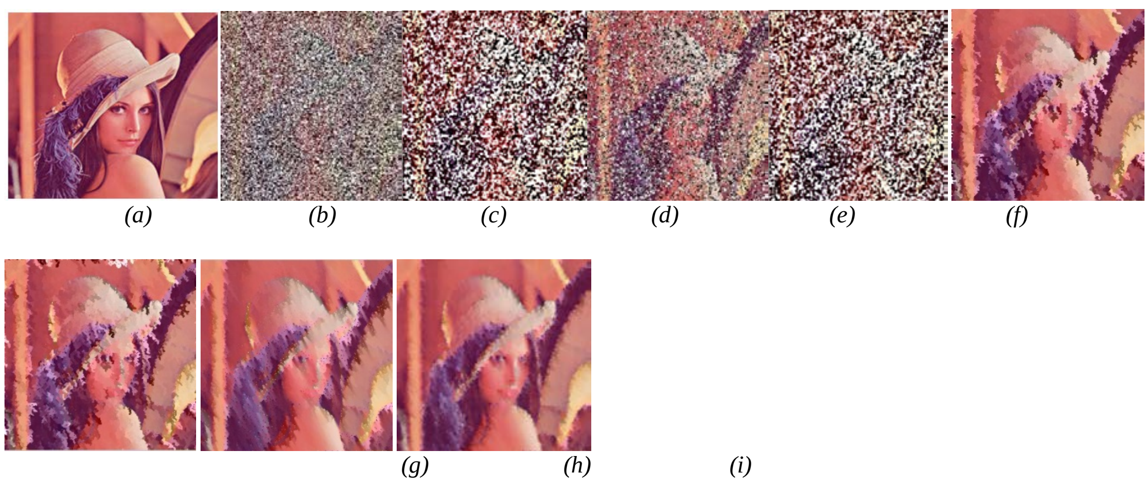


*Figure 7 Results for 90% noise corrupted lena color image (a) Orginal image (b) Noise image (c) MF (d) AMF (e) PSMF (f) DBA (g) MDBA (h) MDBUTMF (i) MNF*

## 6. CONCLUSION

A new algorithm has been proposed to address the problems, namely, poor noise removal at high noise density, which are commonly encountered in SMFs. Results reveal that the proposed filter exhibits better performance in comparison with SMF, DBA, MDBA, MDBUTMF, filters in terms of higher PSNR and IEF. In contrast to AMF and other existing algorithms, the new algorithm uses a small 3x 3 window having only neighbors of the corrupted pixel that have higher correlation; this provides more edge details, leading to better edge preservation. The New algorithm filter also shows consistent and stable performance across a wide range of noise densities varying from 10%-90%. Effective noise removal can be observed even up to 90% compared to MDBUTMF.

The performance of the algorithm has been tested at low, medium and high noise densities on both gray scales as well as color images. Even at high noise density levels the new algorithm gives better results in comparison with other existing algorithms.

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