Noise Reduction of High Density Impulse Noise using First Order Neighborhood Mean Filter

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ABSTRACT- **In this paper, a new algorithm has been proposed for the restoration of gray scale and color images which get highly corrupted by fixed value impulse noise (salt and pepper). This paper is designed to get better result at high density noise in corrupted images. There are two steps in the proposed algorithm for de-noising the image first step is to detect that the pixel is corrupted or not and the second step is to replace the pixel if it is corrupted by mean of its neighborhood pixels. The proposed algorithm considers first order neighborhood pixels for detecting the noisy pixel and mean filter is considered. Proposed algorithm is compared with all other standard and well known algorithms and found to have better result at high noise densities i.e. 80-90%. The proposed algorithm shows better results than Median Filter (MF), Adaptive Median Filter (AMF), Progressive Switched Median Filter (PSMF), Decision Based Algorithm (DBA), Modified Decision Based Algorithm (MDBA), Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF), and Modified Non-Linear Filter (MNF). Different grayscale and color images are tested by using the algorithm and it gave better Peak Signal Noise Ratio (PSNR) and Image Enhancement Factor (IEF) at low, medium and high noise densities.**

Keyword- Salt and Pepper (SNP), Mean Filter (MF), Peak Signal Noise Ratio (PSNR), Mean Square Error (MSE), Image Enhancement Factor (IEF)

1. INTRODUCTION

In digital image processing image enhancement is one of the important stages for processing the image and making it noise free and visually pleasant. Different techniques are used for enhancement two of them are spatial domain technique and frequency domain technique. Spatial domain techniques works directly on the manipulation of image pixels whereas frequency domain is based on modifying the Fourier or wavelet transform of image. When manipulation is done directly on image pixels and if the image is noisy then de-noising is performed in two parts detection of noise and removal of that particular noise were noise is unwanted information that corrupts the image. It generally comes from sensors, environmental conditions (rain, snow, lightening etc.) and transmission through noisy channel. There are different types of noise with which the image can get corrupted. One of them is impulse noise which can damage the image pixels and make the image visually unpleasant. There are two types of impulse noise fixed value and random value [1]. Fixed value is salt and pepper noise where appearance of noise is as white and black dots superimposed on the image. Salt and pepper noise has intensity of corrupted pixels as either relatively high i.e. 255 or low i.e. 0. Here 0 refers to pepper as it is a black dot and 255 refer to salt as it is a white dot. So the name of this impulse noise is given as salt and pepper noise. In the presence of this noise the image gets corrupted. Therefore, this type of noise is to be removed as it is critical for the extraction of accurate and reliable information from the images [2]-[3].

2. LITERATURE SURVEY

Several filters have been proposed for removing the noise from the images that are corrupted by impulse noise and they are the best option to remove noise as they are easy to implement on hardware. Spatial filters are used that are based on ordering the pixel value they include mean filters and median filters. Many researchers have suggested various filtering techniques for removing salt and pepper noise. Among these Standard Median Filter (SMF) is easy to implement and is also reliable. However, its major drawback is that this filter is effective only at low densities. When density level is increased over 50% then the edge details of original image is not preserved [4]. To overcome this drawback several methods have been proposed to remove salt and pepper noise in high densities. Filtering with 3X3 mask is used for keeping the computation time of implementation minimum. Use of small filtering window for removing noise is insufficient. So, Adaptive Median Filter (AMF) has been proposed where the filtering window size is expanded pixel by pixel to get noise free pixel. This filter performs well as low densities. But at high densities the expansion of window size leads to blurring of image [5]. After that researchers have introduced switching median filter [4], [7]. This filter uses predefined threshold value for recovering the corrupted image. Major drawback of this filter is that defining robust decision is difficult and details and edges are not recovered at high densities noise level.

To overcome the above filters drawback Decision Based Algorithm (DBA) has been proposed [8]. In this algorithm image is de-noised using 3x3 window. Here the pixel is processed only if its value is either 0 or 255 otherwise it is left unchanged. At high density noise level this leads to median value of 0 or 255 which is again noisy.

In such case neighborhood pixel is used for replacement. But this repeated replacement of neighboring pixel produces streaking effect [9]. In order to avoid this drawback, Decision Based Un-symmetric Trimmed

Median Filter (DBUTMF) [10] is proposed. In this filter instead of removing from neighborhood pixel un-symmetric trimmed median value is used. At high densities if the selected window contains all 0 or 255 or both then trimmed median value cannot be obtained. So this results bad at high densities that is at 80% to 90%. To avoid this we go for Modified Decision Based Un-symmetric Trimmed Median Filter (MDBUTMF) [11]. It yields better results than all previous algorithms at high densities with better Peak Signal-to-Noise Ratio (PSNR) and Image Enhancement Factor (IEF) values.

The outline of the paper is structured as follows. Section 3 describes proposed algorithm and the steps that are involved in the algorithm. The detailed description of proposed algorithm is involved in Section 4. Simulation results with different images are presented in Section 5. Finally in Section 6 conclusions are given.

3. PROPOSED ALGORITHM

The proposed algorithm processes each and every pixel of an image by detecting the noisy pixel in the image. Processing pixel is checked whether it is noisy or noise free by verifying that the pixel lies between maximum (255) and minimum (0) grey level values. If the pixel is in between the range of grey level then the pixel is noise free otherwise the pixel is corrupted pixel and it is processed to be replaced with the noise free pixel value. Uncorrupted pixels that lie in the range are left unchanged. The steps for the algorithm are as follows:-

Step 1: First we take an initial image and apply on it fixed valued impulses noise (Salt and Pepper noise).

Step 2: In the second step check whether the pixels are between 0 to 255 ranges or not, here two cases are generated.

Case 1- If Pixels are between 0< Y (i,j)<255 then, they are noise free and move to restore the image.
Case 2- If the pixels are not lying between in the range then they are moved to step 3.

Step 3: In the third step we will work on noisy pixel of step2 by selecting window of size 3 x 3 of the image. Assume that the targeted noisy pixels are X (i,j), that is processed in the next step.

Step 4: If the preferred window contains not all elements as 0's and 255's. Then remove all the 0's and 255's from the window, and send to restore the image. Now find the mean of the remaining pixels. Replace X (i,j) with the mean value. This noised removed image restores in de-noised image at the last step.

X(i,j) = [00] condition true send to Y (i,j) for Restoration

X(i,j) = [255] condition true send to Y (i,j) for Restoration

[Cal. Mean remain (X (i,j)) pixels] = replace by W (i,j)

Step 5: Repeat steps one to three until all pixels in the whole image are processed. Hence a better de-noised image is obtained with improved PSNR, IEF and also shows a better image with very low blurring and improved visual and human perception.

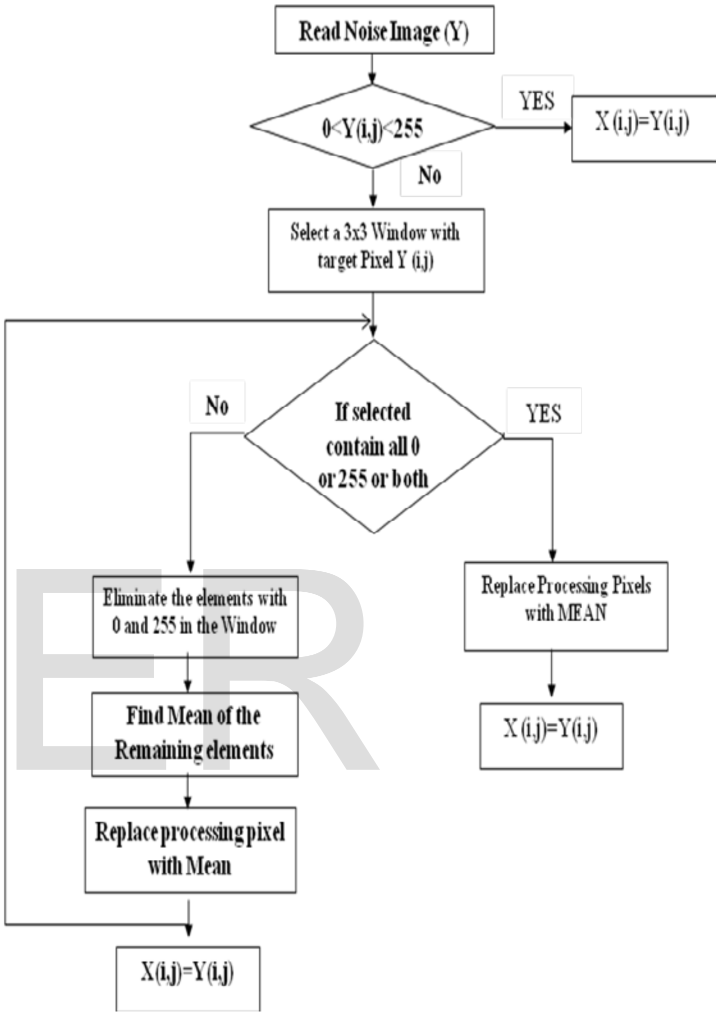


Figure 1. Flowchart for proposed algorithm

4. ILLUSTRATION OF Proposed Algorithm

Each and every pixel of the image is processed and checked for the presence of fixed valued impulse noise (salt and pepper noise). Different cases are illustrated in this section. If the processing pixel is noisy and all other pixel values are 0's or 255's this is illustrated in Case i). If the processing pixel is noisy and not all pixel values are 0 or 255 is illustrated in Case ii). If the processing pixel is not noisy and all the other pixel values lie between 0 and 255 this is illustrated in Case iii).

Case i): If the selected 3x3 window contains 0 or 255 noise as processing pixel (i.e. salt or pepper noise) and all the neighboring pixels value are also 0 or 255. This adds the salt and pepper noise to the image:

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

where '255' is the processing pixel, i.e. (P_{ij}).

Since all the pixels surrounding (P_{ij}) are 0's and 255's. If the median of pixels is taken it will gave the processing pixel value as 0 or 255 which is again noisy. So the processing pixel P_{ij} will be replaced with the mean of all the neighboring pixels in the selected window.

Case ii): If the selected window contains 0 or 255 noise as processing pixel (i.e. salt or pepper noise) and not all the neighboring pixels value are 0 or 255. This adds the salt and pepper noise to the image:

$$\begin{bmatrix} 98 & 129 & 0 \\ 255 & (0) & 83 \\ 67 & 106 & 255 \end{bmatrix}$$

where '0' is processing pixel, i.e.(P_{ij}).

Now salt and pepper noise is removed from the selected window by removing the pixel value 0 and 255. The one dimensional array of the above matrix is [98 129 0 255 0 83 67 106 255]. After the noise is removed the array will be [98 129 83 67 106]. Here the mean value of all these pixels is taken and the processing pixel P_{ij} is replaced by the mean.

Case iii): If the selected window contains a noise free pixel as the processing pixel then it does not require any changes and it is left unchanged. For example if the processing pixel is 75 then it is noise free pixel:

$$\begin{bmatrix} 99 & 43 & 128 \\ 104 & 75 & 65 \\ 68 & 52 & 87 \end{bmatrix}$$

where '75' is the processing pixel, i.e. (P_{ij}).

Since it a noise free pixel it does not require any processing and left unchanged.

5. SIMULATION RESULTS AND COMPARISION

We have used Matlab R2012b as the simulation tool. Performance of the proposed algorithm is tested with different grey scale and color images. The images are corrupted by fixed value impulse noise i.e. salt and pepper noise. Performances are quantitatively measured with various noise densities for Peak-Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE) and Image Enhancement Factor (IEF) defined (1), (2) and (3) respectively:

$$PSNR = 10\log_{10}\frac{(255)^2}{MSE} \quad (1)$$

$$MSE = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\{Y(i,j)-\hat{Y}(i,j)\}^2}{m \times n} \quad (2)$$

$$IEF = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\{\eta(i,j)-Y(i,j)\}^2}{\sum_{i=1}\sum_{j=1}\{\hat{Y}(i,j)-Y(i,j)\}^2} \quad (3)$$

Here m x n is the size of the image. Y (i, j) represents the original image and $\hat{Y}$ (i, j) represents de-noised image and η (i, j) represents noisy image. The noise density is varied from 10% to 90%. The results show improved performance.

The figure 2, 3 and 4 shows the graphical representation of Lena and Mandrill image. The graph shows the comparison of PSNR and IEF of proposed algorithm with other existing algorithms. Figure 3, 4 shows the results of grayscale Lena image at 80% and 90% noise density. Figure 5, 6 shows the results of color Lena image at high density noise i.e. 80% and 90%. Figure 7, 8 shows the result of Mandrill image at 80% and 90% noise density.

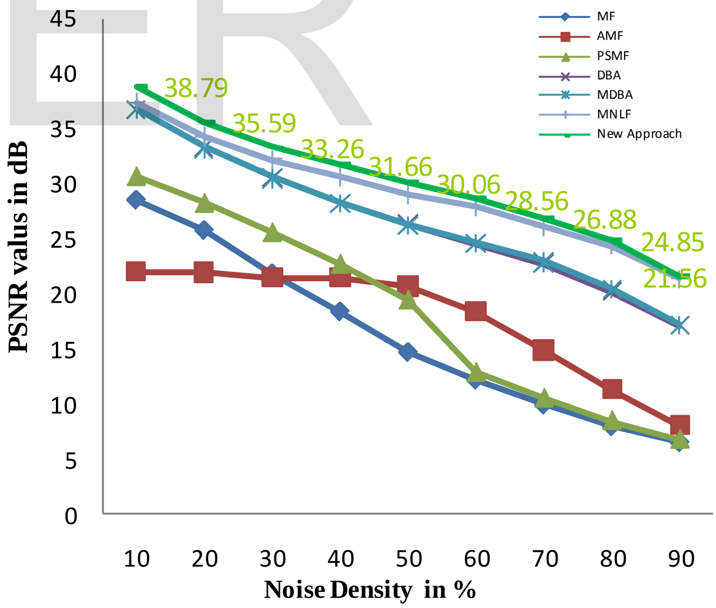


Figure 2. Noise density versus PSNR (db) for Lena image

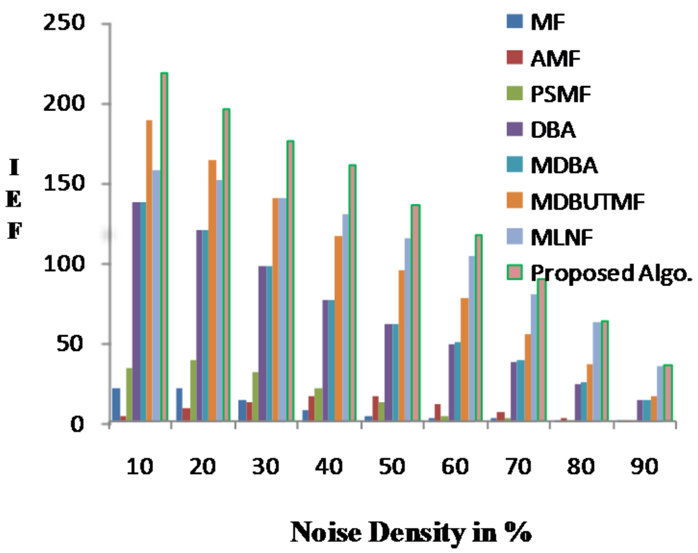


Figure 3. Noise density versus IEF for Lena image

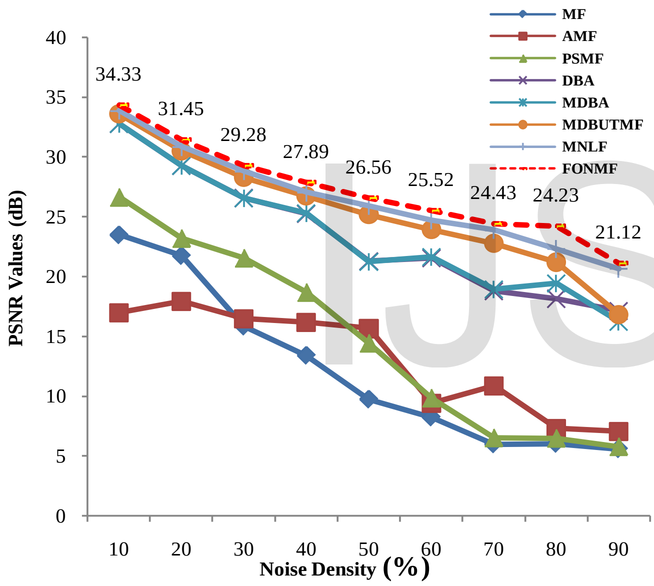
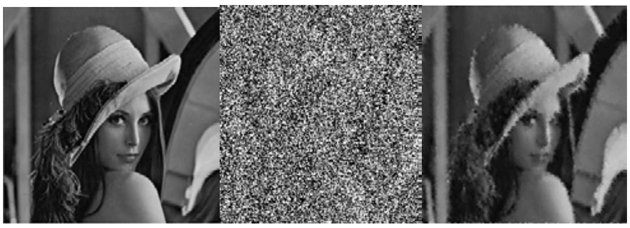


Figure 4. Noise density versus PSNR (dB) for Mandrill image



(a) **(b)** **(c)**

Figure 3 Results for 80% noise corrupted lena image (a) Original image (b) Noisy image (c) Proposed Algorithm

(a) **(b)** **(c)**

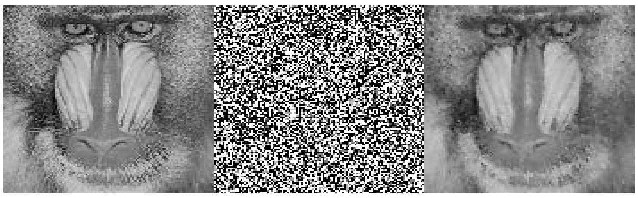
Figure 4 Results for 90% noise corrupted lena image (a) Original image (b) Noisy image (c) Proposed Algorithm

(a) **(b)** **(c)**

Figure 5 Results for 80% noise corrupted lena color image (a) Original image (b) Noisy image (c) Proposed Algorithm

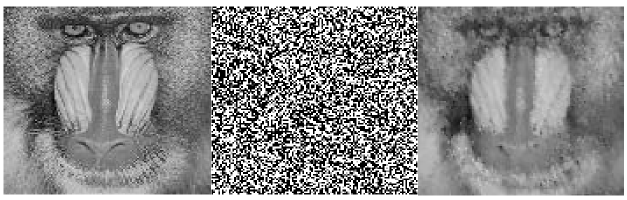
(a) **(b)** **(c)**

Figure 6 Results for 90% noise corrupted lena color image (a) Original image (b) Noisy image (c) Proposed algorithm



(a) **(b)** **(c)**

Figure 7 Results for 80% noise corrupted Mandrill image (a) Original image (b) Noisy image (c) Proposed algorithm



(a) **(b)** **(c)**

Figure 8 Results for 90% noise corrupted Mandrill image (a) Original image (b) Noisy image (c) Proposed algorithm

6. CONCLUSION

A new algorithm has been proposed for poor noise removal at higher densities noise. This algorithm gives better results than MF, AMF, PSMF, DBA and other existing algorithms in terms of PSNR and IEF. The image performance has been tested at low, medium and high densities noise on both grayscale and color images. At high density level this algorithm provides better results in comparison with other existing algorithms. Due to limited window size it requires less computing time. The proposed algorithm is effective for fixed valued impulse noise i.e. salt and pepper noise.

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