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"Impulse Noise Removal with fixed value for Adaptive Improved Median Filtering"

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Abstract--In the sector of image processing, elimination of noise from digital images plays very vital role. Effective detection of noisy pixel based on median value calculation and an efficient algorithm for the estimation and replacement of noisy pixel again based on median value calculation of noise-free pixels has been carried out in our proposed method. In this paper we use the improved median filter for removal of impulse noise, especially for the high-density fixed value impulse noises.

Index Terms— Peak signal to noise ratio, fixed valued impulse noise, switching median filter.

I. INTRODUCTION

Image processing is an important area in the information industry. [7] Image de-noising has been one of the most important and widely studied problems in image processing and computer vision. It refers to the task of recovering a good estimate of the true image from a degraded observation without altering and changing useful structure in the image such as discontinuities and edges. Impulse noise is one of very common and intensive noise, which effects the images during the acquisition, transmission and processing of images.[1] Impulsive noise can be Salt & Pepper Noise (SPN) or Random Valued Impulsive Noise (RVIN).The need to have a very good image quality is increasingly required with the advent of the new technologies in a various areas such as multimedia, medical image analysis, aerospace, video systems and others. Obviously it is impossible that there is no noise in the image. So it is important to eliminate the noise before the further process. We can first apply the median filter (MF) to the corrupted image. The median filter is by far the most useful order-statistic filter [12].Nevertheless, to one's disappointment is removing fine details tendency for MF.

More important, the MF's result depends on the filter window size and the number of involved pixels. The challenge is to design methods, which can selectively smooth a degraded image without altering edges, losing significant features and producing reliable results. Some methods focused mostly on SNR arguments without taking into account the strength of natural image priors. The de-noising method aims to attenuate noise through two phases namely,

1. Noise detection and
2. Noise removal

The noise detection part is applied to every component once this part, noise removal replaces the corrupted pixels of the input image by the acceptable values that area unit computed from such values. Median filter is commonest non-linear filter .The most plan behind the conception of median filter is sorting. This filter offers the higher results than mean and alternative linear filters. However it conjointly has disadvantage that this filter works uniformly over the complete image. That causes blurring into the image. that's why some modifications are created in common place median filter to induce higher results.. Weighted median filter (WMF) [6] is an primarily modified median filter. Some other filters are Adaptive median filter (AMF), Adaptive weighted median filter (AWM) [6], Switching median filter (SMF). It can be seen that combining the median filter with other filters to improve the performance of median filter such as

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median filter combine with average filtering or median filter combine with high pass filter.

II. IMPULSE NOISE MODEL

Impulse noise is modeled as salt-and-pepper noise.[3] [1] Pixels are randomly corrupted by two fixed values, 0 and 255 generated with the equal probability. We can mathematically represent salt-and-pepper impulse noise as:

$$N(x) = \begin{cases} B/2 & \text{for} \cdots x = 0 \\ 1 - B & \text{for} \cdots x = W(i,j) \\ B/2 & \text{for} \cdots x = 255 \end{cases} \quad ....(2)$$

Where $W_{i,j}$ is the gray level value of the noisy pixel.

III. RELATED WORK

Median Filter:-

The Simple Median Filter has an advantage over the Mean filter in that it relies on median of the data instead of the mean. A single noisy pixel present in the image can significantly skew the mean of a set. The median of a set is more robust with respect to the presence of noise. The standard median filter works effectively for low noise densities but at the cost of blurring the image. The spatial domain the most basic nonlinear filter is the standard median filter (MF)[1]. It replaces each pixel in the image by the median value of the corresponding filtering window. The drawback of linear filters can be overcome by median filter. [8] Median filter has edge preserving quality during the noise reduction. It used NxN size of filtering window for noise removal, where N is odd. This NxN matrix contains N^2 element. Median filter operation first sorts all the elements of filtering window, than it select the central element of that sorted sequence called median value. The central pixel of filtering window will than replaced with this median value. [2]The function of median operation can be written as

$$\text{Median}(W) = \text{Med}\{Wi\}$$
$$= \begin{cases} Wi(n+1)/2, & n \text{ is odd} \\ \tfrac{1}{2}[Wi(n/2) + Wi(n/2)+1], & n \text{ is even} \end{cases} \quad ....(8)$$

Where W1, W2, W3 ………... WN is the sequence of neighbour pixels. First all the elements are sorted in ascending or descending order like Wi1≤Wi2≤Wi3≤....................WiN, than take the central element to replace with central pixel. Median filter has good performance to remove Impulse noise.

Rank Order Mean Filter (ROM) [11]:

In the ROM based switching scheme, multiple thresholds are used in impulse detection that operates on the differences between the current pixel and the remaining rank-ordered elements in the filter window. It has been shown to work well in removing both types of impulses. It is an efficient nonlinear algorithm to suppress impulse noise from highly corrupted images while preserving image details and features. The method is applicable to all impulse noise models, including fixed valued (equal height or salt and pepper) impulses and random valued (unequal height) impulses, covering the whole dynamic range. The technique achieves excellent tradeoff between the suppression of noise, and preserving the details and edges without undue increase in computational complexity.

Laplace Equation based Adaptive Median Filter[4]:-

This filter is based on adaptive median filter.it is also used for removing the impulse noise .In this fiter fixed value impulse noise are used.This filter divides the entire corrupted image into square sub images of order of n×n with overlapping. Where n is an odd number. These sub images are normally known as filtering window (W). In each window, first of all we checked that the central pixel is corrupted or not. If central pixel is not corrupted, the filtering window moves to the next pixel and otherwise, central pixel is treated with the filtering method LEAM filter. In order to restore the original pixel value of the corrupted image, the filter selects the noise-free pixels of filtering window and calculates the median of window W. Then, this filter computes the average of the pixels of filtering window by PDE, prior to which they are replaced by median, if they were corrupted. This process is repeated for the entire sub image of the noisy image.

Adaptive switching median filter (ASMF)[9]:-

The adaptive median filtering has been applied widely as an advanced method compared with standard median filtering. The Adaptive Median Filter performs spatial processing to determine which pixels in an image have been affected by impulse noise.This process is computationally efficient to remove

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impulse noise or salt & pepper noise. This is an improvement in Switching median filter [5] (SMF). This process contains two steps, first one is noise detection, and other one is noise removal. It has a property of adaptively change in the size of filtering window according to the noise density. [10] At the starting of de-noising process, it selects smallest size (3x3) of filtering window. The central pixel (f_i) of filtering window is compared with minimum and maximum value of that window. If f_i > minimum and f_i < maximum, then the pixel will left unchanged. If f_i < minimum and f_i > maximum, then central pixel will considered as noisy and will be replaced by median value of window. If f_i = minimum and f_i = maximum, then there may be noisy pixel or may have smooth area. For the further detection, size of filtering window is increased and then again detection process performed. If the central pixel is a part of smooth area, then it will left unchanged, otherwise it replaced with median of that window. The size of filtering window increases up to a limited level.

IV. PROPOSED METHOD

The main challenge in De-noising is to removal of impulsive noise as well as preserving the image details. Our schemes utilize detection of impulsive noise followed by filtering. In the filtering without detection, a window mask is moved across the observed image. The mask is usually of size $(2N+1)^2$, where N is a positive integer. Generally the centre element is the pixel of interest. We have developed the simple algorithm in which we perform the noise detection & noise removal process more effectively. We divide these pixels into matrix form and called it window. Then we analyses every pixel by sliding that window over the entire image. The window of size 5x5 chooses for noise detection and noise removal. The window contains total 25 elements which are as follows:

In this method, we have used median filter for de-nosing the impulse noise. Because we use the fixed value impulse noise the minimum and maximum threshold value are fixed i.e. 0 and 255.This minimum and maximum threshold value are used for detecting the noise and median value used for noise removal. This de-noised method uses small window size (5x5) to remove the noise and preservation of image fine details. For this purpose, first we detect noise in the all pixels of filtering window on by on then we separate the noisy pixels and noise-free pixels. Noisy pixels will be used to represent density of noise in the filtering window and then noise free pixels will be used to find median value to replace the noisy pixels. The complete de-noising process can be dividing in following number of steps:

Step-1:-

We will start with smallest size of filtering window i.e. 5X5. We have twenty five elements in filtering window. Now we use minimum and maximum threshold values i.e. 0 and 255 for detect noise and level of noise density. First we compare all 25 elements to 0 and 255 fixed values.

Table 1. Filtering window of size 5x5

	Column 1	Column 2	Column 3	Column 4	Column 5
Row 1	A_1	A_2	A_3	A_4	A_5
Row 2	A_6	A_7	A_8	A_9	A_{10}
Row 3	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}
Row 4	A_{16}	A_{17}	A_{18}	A_{19}	A_{20}
Row 5	A_{21}	A_{22}	A_{23}	A_{24}	A_{25}

Step 2:-

Now we will compare the all 25 pixel with these threshold fixed value i.e. 0 and 255. If the value of pixels lies within the threshold values, then the pixel is consider as noise-free otherwise it is consider as noisy. It can explain by following algorithm:

If

$Thmin<A_{13}<THmax$

Then

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A_{13} is noise-free;

Else

A_{13} is noisy.

Step-3:-

After noise detection, if the central pixel is noise-free then we move to the next pixel by sliding the filtering window. If the central pixel is noisy, then, we start noise removal operation for that pixel. We compare all elements of filtering window with 0 and 255 and separate the noisy pixels and noise-free pixels in two different groups, one for noise free pixels and another for noisy pixels. Then we find the median value of noise free pixels and replace it with noisy central pixel in the filtering window.

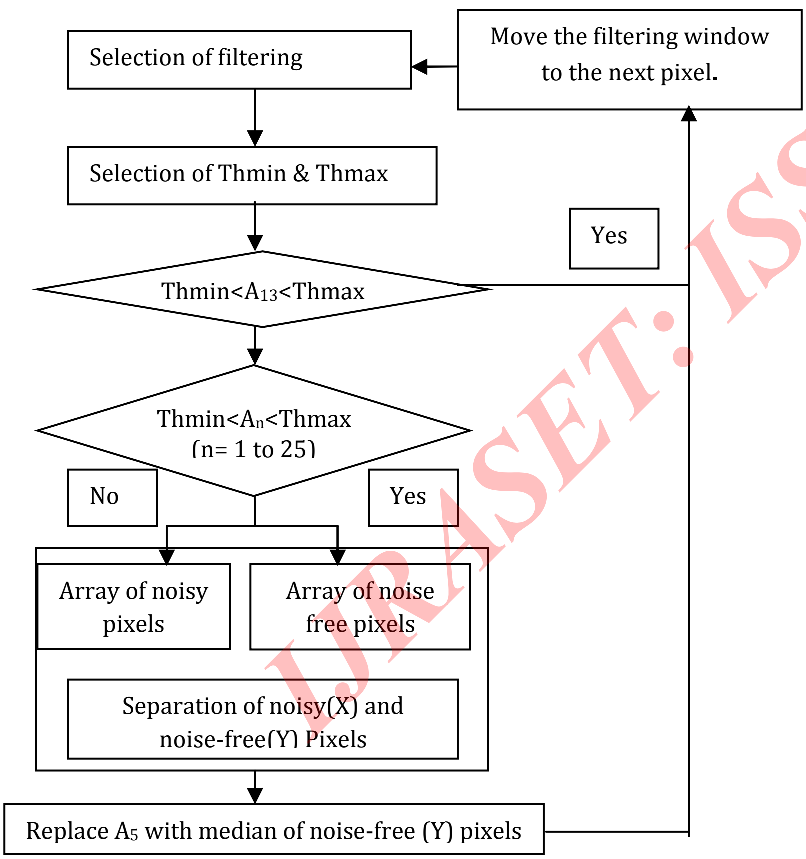

Figure 1: Flow chart of complete process

V. SIMULATION AND RESULTS

Using this method, we have performed image de-noising on BIST image and real image CAKE of size 256x256 and simulate results on MATLAB 7.5. For different noise density levels (50%-90%), the resultant PSNR is shown in table 2 and 3, and we made a comparative analysis based on this peak signal to noise ratio (PSNR) of de-noised image. The proposed method measured as PSNR is compared with a few high performing median based filters namely, Simple Median Filter, Rank Order Mean Filter (ROM), Laplace Equation based Adaptive Median Filter (LEAM), Adaptive switching median filter (ASMF) It is apparent from Table 2 and 3 that the proposed filter produces lower PSNR values with respect to MF and higher PSNR values than the other filters.

For the de-noised image, Z of size M×N, the PSNR[6] will be

$$PSNR = 10\log_{10}\frac{(255)^2}{MSE}\ \text{db}$$

Where MSE (Mean square error), is

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

With respect to the noise-free original image A.

The results in the table 2 and table 3 clearly show that the PSNR of proposed method is better noise density as compare to ASMF, ROM and LEAM filters. As the density of noise increasing, the response of proposed filter is becomes better in comparison of those filters. This method is tested on BIST image and real image CAKE shown in figure 4 and figure 5.

In the Table 2 shown below, we compared the PSNR of different median filters i.e. Median filter (MF) [8], Rank order median filter (ROM) [11], Adaptive Switching Median filter (ASMF) [9], Laplace Equation based adaptive Median Filter (LEAM) [4].

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Table 2. Comparison of PSNR values of different filters for BIST image

De-noising Methods	Noise density				
	50%	60%	70%	80%	90%
MF	10.729	9.6699	8.4899	7.3508	6.182
ASMF	7.2212	6.4332	6.224	5.4431	5.1215
ROM	7.3342	6.5534	6.111	5.5567	5.101
LEAM	7.461	6.6881	6.2213	5.6632	5.1123
Proposed	7.7318	6.9717	6.3084	5.7382	5.2338

In table 3 shows that proposed filter produce low PSNR than Median filter (MF) and high PSNR than the other filters like Rank order median filter (ROM), Adaptive Median filter (AMF), Laplace Equation based adaptive Median Filter (LEAM).

Table 3. Comparison of PSNR values of different filters for real image CAKE.

De-noising Methods	Noise density				
	50%	60%	70%	80%	90%
MF	11.3472	10.2624	9.15326	8.02902	6.83846
ASMF	8.0012	7.1552	6.7768	6.2369	5.34429
ROM	8.3313	7.5523	6.6678	6.33102	5.82242
LEAM	8.1212	7.3453	6.8812	6.2134	5.65184
Proposed	8.34484	7.5769	6.90516	6.33395	5.82962

The Graphical representation of PSNR values of different filters shown in Figure 2 and figure 3

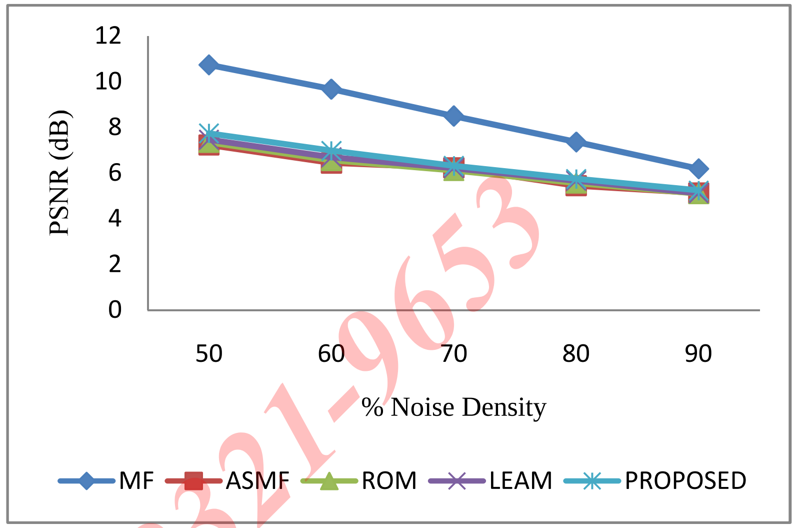

Figure 2: Graphical representation of PSNR (dB) of different filters at different noise density for BIST Image.

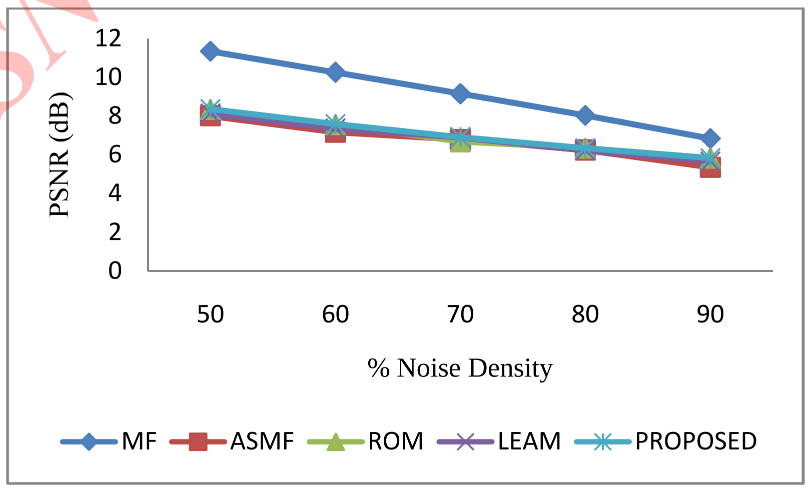

Figure 3: Graphical representation of PSNR (dB) of different filters at different noise density for real Image CAKE

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This method is tested on BIST image shown in figure 4 corrupted by fixed valued impulse noise. The figure show Original image, Noisy image and De- noised image at 50%. From the visual outputs, it is very clear that image de-noised by proposed method has good quality.

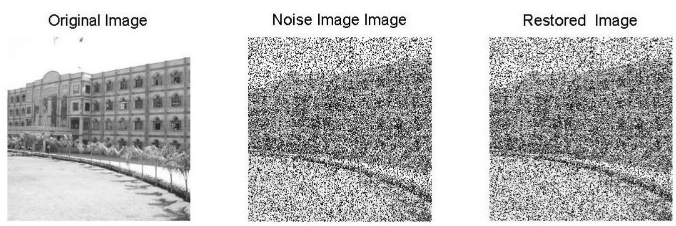

Figure 4: 50 % De-noised Image

The image de-noising results for real image CAKE is shown in the figure 5 show Original image, Noisy image and De- noised image at 50%.

Figure 5: 50% De-noise image

VI. CONCLUSION

The proposed filter is proved to be effective in re-storing the images corrupted with fixed-value impulse noise 50% to 90% of probability. This filter finds application in eliminating noise from Scanning Electron Microscope (SEM) images, used in the study of surface morphology, because SEM images are invariably degraded by fixed value impulse noise.We have used the concept of maximum and minimum fixed threshold value i.e. 0 and 255 to detect both positive and negative noise. It produces good PSNR (Peak Signal to Noise Ratio) for highly corrupted images, especially for more than 50% noise density. This algorithm is simple and has efficient detection algorithm than other filtes liks ASMF, ROM, and LEAM etc. Better filtering method gives advantage of preservation of fine details of image. This filter will have great application in the field of image processing. The proposed method improved the quality of de-noised image especially for fixed valued impulse noise

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