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High Density Salt and Pepper Noise Removal in Images Using Adapted Decision Based Unsymmetrical Trimmed Mean Filter Cascaded with Gaussian filter

Prakriti Thakur[1], Jitendra Rajpurohit[2], Rekha Chaturvedi[3]

[1]Amity University,
Jaipur, Rajasthan
erprakriti0007@gmail.com

[2] Amity University,
Jaipur, Rajasthan
jrajpurohit@jpr.amity.edu

[3] Amity University,
Jaipur, Rajasthan
rchaturvedi@jpr.amity.edu

Abstract: ***An adapted decision based unsymmetrical trimmed mean filter cascaded with Gaussian filter (ADCG) algorithm for the retrieval of gray scaled image which is induced by a very high density Salt and Pepper (impulse) noise is proposed and tested in this paper.***
The proposed calculation supplants the noisy pixel by trimmed mean quality when other pixel values, 0's and 255's are available in the selected window and when all the pixel qualities are 0's and 255's then the noisy pixel is supplanted by mean estimation of the considerable number of components present in the selected window. This proposed methodology shows preferred results over the Standard Median Filter (MF), Decision Based Algorithm (DBA), Modified Decision Based Algorithm (MDBA), Progressive Switched Median Filter (PSMF) and Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF). The proposed methodology is tried against distinctive pictures and it gives better PSNR that is Peak Signal-to-Noise Ratio.

Keywords: mean filter, salt and pepper noise, unsymmetrical trimmed mean filter, cascaded filter**.**

1. Introduction

IMPULSE noise in pictures is attributable to bit errors in transmission or introduced throughout the signal acquiring stage. Impulse noise can be classified in two types i.e. they are salt and pepper noise and random value impulse noise. Salt and pepper noise taints (contaminates) the pictures wherever the contaminated picture component takes in any of the gray level that is maximum or minimum gray level. Numerous nonlinear filters are anticipated for image restoration, which is if it gets contaminated by noise of type salt and pepper. Among these, normal median filter (MF) has been set up as dependable philosophy to dispose of the salt and pepper noise while not harming the sting details. When the noise density is low then the outcome of the above said filter is very good but at the same time it is also a drawback that the performance of median filter is not good if the noise density increase even up to 20%. Another major issue with median filter is that when noise density increases then this filter is not able to preserve the edge details of the image [1]. Adaptive Median Filter (AMF) [2] performs superior to MF at low noise densities. However at high noise densities the window size must be swelled which can bring about image blurring. The benefits of progressive switching middle filter [3][4] is that it doesn't have to process the pixels which is non noisy. The threshold value is the main parameter to take the decision. Furthermore these filters won't take under thought the local alternatives, as a consequence of that, points of interest and edges won't not be regained, especially once the density is high.

The drawback analyzed above can be look after on, Decision Based Algorithm (DBA) was introduced and the detail is given in ref[5]. In this methodology, the contaminated picture is denoised by utilizing a 3×3 matrix. Only those pixels are processed in this scheme which is either 0 or 255, else, it's left unaltered. When density of noise is higher the norms are 0 or 255 that are noisy. In such case, neighborhood pixel part is utilized for substitution. This constant substitution of neighboring components produces streaking result [6].Decision Based Unsymmetrical Trimmed Median Filter (DBUTMF) was

presented [7] to overcome the above problem. At higher noise densities, if the chosen window contains all 0's or 255's or both then, trimmed median quality can't be good option. Along these lines this algorithmic system doesn't offer higher results at frightfully high density of noise that is at 80% to 90%. The Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) algorithmic [8] program uproots this drawback at high density of noise and offers higher Peak signal to noise ratio (PSNR) values than the present algorithmic project. Presently to enhance the calculation and to build the picture quality i.e. PSNR yield of MDBUTMF, it is being gone through a Gaussian channel and result of the proposed calculation that is of ADCG, is terribly improved. Whatever remains of the paper, is organized as followed. A quick overview of unsymmetrical trimmed median filter is given in Section II. Section III describes concerning the planned algorithmic program and completely different cases of planned algorithmic program. The careful description of the planned algorithmic program with an example is given in Section IV. Simulation results with the different images are given in Section V. Conclusion is illustrated in Section VI. And finally Future scope is described in Section VII.

2. Unsymmetric Trimmed Median Filter

The thought behind a trimmed channel is to reject the loud pixel from the chosen 3×3 window. ATMF also known as Alpha Trimmed Mean Filtering is a symmetrical channel [9] where the trimming is symmetric at either end. In this strategy, even the uncorrupted pixels are additionally cut. This prompts loss of picture's points of interest, edges and obscuring of the picture. So as to conquer this downside, an Unsymmetric Trimmed Median Filter [10] (UTMF) was proposed. In this UTMF, the chosen 3 × 3 window components are organized in either expanding or diminishing request. At that point the values of pixel that is 0's and 255's in the picture (i.e., the pixel values in charge of the salt and pepper noise) are expelled from the picture. At that point the average estimation of the remaining pixels is taken. This average quality is utilized to supplant the uncontrollably noisy pixel. This channel is called trimmed average channel in light of the fact that the pixel values 0's and 255's are expelled from the chosen window. This system uproots noise in preferred path over the ATMF.

3. Proposed Algorithm

The proposed adapted decision based unsymmetrical trimmed mean filter cascaded with Gaussian Filter (ADCG) method forms the tainted pictures by first distinguishing the Salt and Pepper contamination. The very first step is the checking of the input processing pixel that whether it is noisy or not. To certify that whether the input processing pixel is noisy or not we have to check that if it comes between the lower limit or maximum limit of gray scale level and of it lies in between then it should be left unaltered or intact. In the event if the handling pixel takes the most extreme or least gray level then it is a corrupted pixel. The steps of the proposed algorithm are described as follows.

Each and every pixel element of the image under observation is performed replacement with, if necessary for the presence of salt and pepper noise. Required cases are shown in this Section. If the processing pixel is noisy and all other pixel elements are 0's or 255's is shown in case i). If the processing pixel is noisy pixel that is 0 or 255, it is illustrated in case ii). If the processing pixel is not noisy pixel and its value lies between 0 and 255, it is explained 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 as shown below:

3.1 Algorithm

Step 1: In the very first step we have to select 3x3 windows in 2D. Let us take the pixel to be processed as Pij. Here i represent the row index and j represents the column index in input contaminated image.

Step 2: If selected window will carry all the processing value in the window as a non noisy pixel, then its value will left unchanged. This is discussed in Case III of Section IV.

Step 3: In case of processing pixel being corrupted, two cases are possible as explained in Case i) and ii).

Case i): If the selected window contains all the elements as 0's and 255's, here taking the median of all elements present in the window will not be effective outcome, as median of 0 and 255 will either be 0 or 255, which is again a noisy pixel. Thus apply the mean operation and replace Pij with the resultant value.

Case ii): If the selected window contains not all elements as 0's and 255's. Then eliminate 255's and 0's and find the mean value of the remaining elements. Replace Pij with the mean value.

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

Step 5: The denoised image is finally passed through the Gaussian Filter.

The flowchart representation of each case of the proposed algorithm is shown in Fig. 1. The detailed description of each case of the flow chart shown in Fig. 1 is illustrated through an example in Section IV.

4. Illustration of the Proposed Algorithm

The proposed algorithm is well explained with the help of illustrations provided in each case. According to the pixel elements provided in the selected window, further processing is done.

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

where"255" is processing pixel, i.e (2,2).

Since all the elements in the surrounding window 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, calculate the mean of the selected 3×3 window and the processing pixel is thus replaced by the mean value.

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 (but not all) pixels that adds salt and pepper noise to the image:

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

Where “0” is processing pixel, i.e., 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 [78 90 120 97 73]. Here the mean value is 91. Hence replace the processing pixel by 91.

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

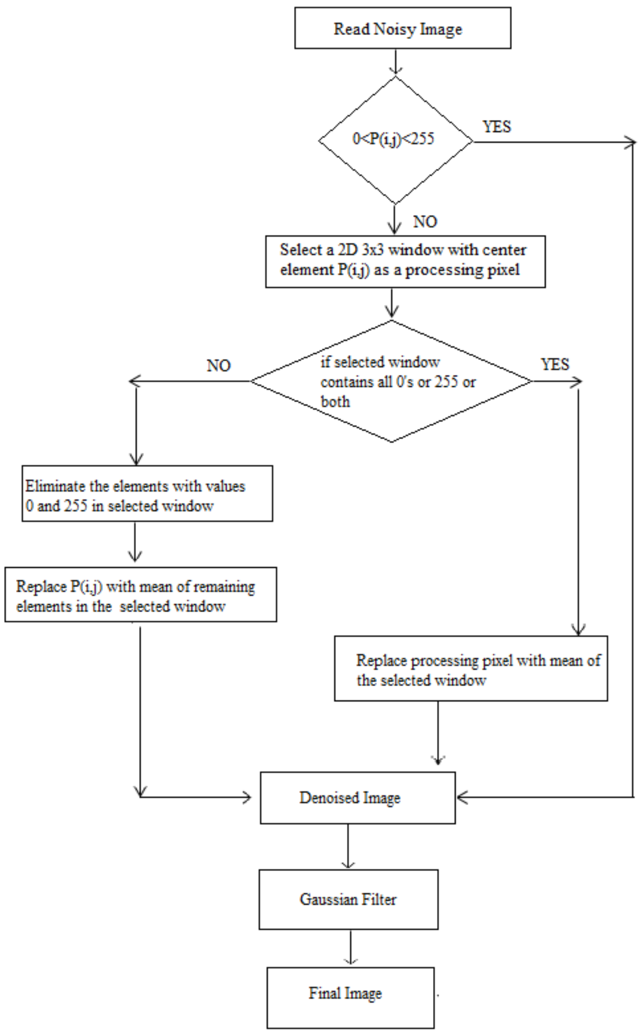


Figure 1: Flow Chart of Proposed Methodology

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

where“90” is processing pixel. Since “90” is a noise free pixel it does not require further processing.

5. Simulated Results

The final image obtained after applying algorithm is tested and compared with the previous results and the corresponding values of the parameters. Noise is varied from 10% to 90%. Denoising performances are quantitatively measured by the PSNR [11] as defined in (1).

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

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

where MSE stands for mean square error, M×N is size of the image, Y represents the original image, Ŷ denotes the denoised image.

Noise in %	PSNR in DB						
	MF	AMF	PSMF	DBA	MDBA	MBUTMF	ADCG
10	26.34	28.43	30.22	36.4	36.94	37.91	37.03
20	25.66	27.40	28.39	32.9	32.69	34.78	34.23
30	21.86	26.11	25.52	30.15	30.41	32.29	33.05
40	18.21	24.40	22.49	28.49	28.49	30.32	31.91
50	15.04	23.36	19.13	26.41	26.52	28.18	30.93
60	11.08	20.60	12.10	24.83	24.41	26.43	29.77
70	9.93	15.25	9.84	22.64	22.47	24.30	28.89
80	8.68	10.31	8.02	20.32	20.44	21.70	28.19
90	6.65	7.93	6.57	17.14	17.56	18.40	28.13

Table1: PSNR of proposed and existing algorithms at 10% to 90% noise density for lena image

The PSNR 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 1. From the Table 1, it is observed that the performance of the proposed algorithm is better than the existing algorithms at both low and high noise densities.

The qualitative analysis of the proposed algorithm against the existing algorithms at different noise densities for Baboon image is shown in figure 2. In figure 2, the first column represents the processed image using MF at 80% and 90% noise densities. Subsequent columns represent the processed images for AMF, PSMF, DBA, MDBA, MDBUTMF and ADCG with same levels of noise densities. Figure 3 shows the original “Lena” image while figure 4 shows the results of ADCG performed on “Lena” at noise densities (a) 60% (b) 70% (c) 80% and (d) 90% respectively. From the figures, it can be concluded that ADCG provides better denoised image quality irrespective of the nature of the input image.

6. Conclusion

Objective proposed in this paper was to analyze and possibly generate the improved methodology for image denoising especially if it is contaminated by salt and pepper noise with high density. The proposed ADCG algorithmic approach is proven to be efficient and useful for this task. Various algorithms are there to do the above said task, but the emphasis is on quality of retrieved image that should be accounted for. Therefore the comparison of resulting image quality with the existing image quality showed that its performance is better in all the available approaches currently extant. Even at the high noise levels of 80-90% the method gives efficient and promising results and thereby can be said that the method is very effective for high density salt & pepper noise removal.

7. Future Scope

The proposed algorithm and separating strategies oblige further research on adjustment techniques with diminished processing time and unpredictability. The handiness of the proposed procedures for discourse, music and remote sensing pictures might be explored. Despite the fact that the proposed exchanging based average separating calculations are compelling in uprooting drive clamor in pictures, there are numerous open inquiries and exploration issues of significant investment. Future experiments can be done on colored or RGB image with a better approach.

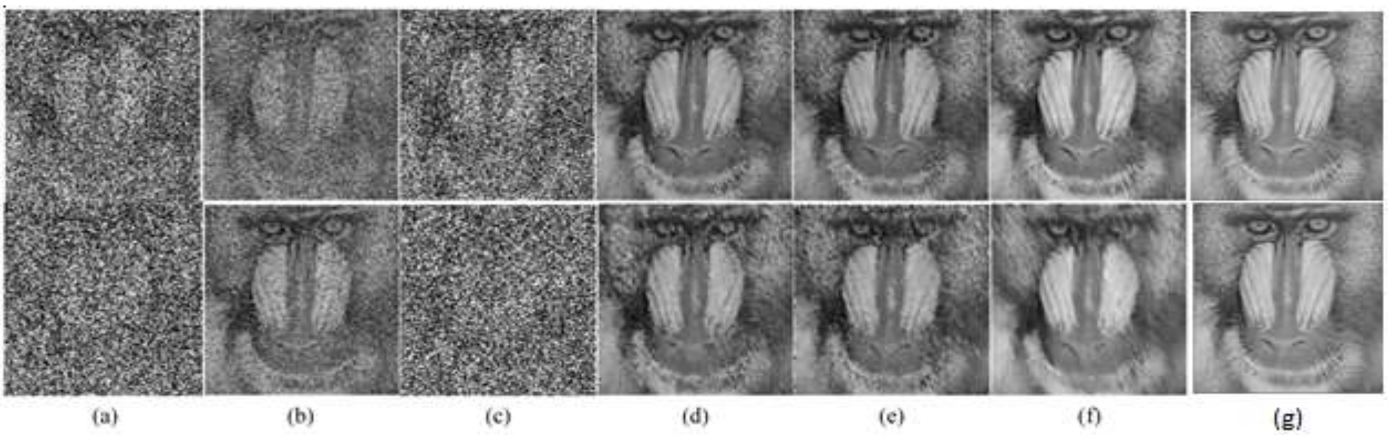
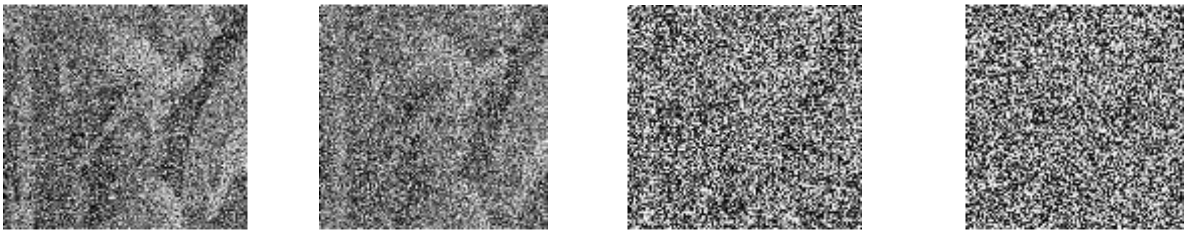


Figure 2: Results of different algorithms for Baboon image. (a) Output of MF. (b) Output of AMF. (c) Output of PSMF. (d) Output of DBA. (e) Output of MDBA. (f) Output of MDBUTMF (g) Output of ADBUTMFG. Row 1 and Row 2 show processed results of various algorithms for image corrupted by 80% and 90% noise densities, respectively.

Figure 3: Original Image"Lena"



(a) (b) (c) (d)

Figure 4: Result of the ADCG Algorithm on Lena Image with different Noise inputs (a) 60% (b) 70% (c) 80% (d) 90%

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