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High Density Salt and Pepper Noise Removal Using Adapted Decision Based Unsymmetrical Trimmed Mean Filter Cascaded With Gaussian Filter

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Abstract: ***An adapted decision based unsymmetrical trimmed mean filter cascaded with Gaussian filter (ADBUTMF) 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 algorithm replaces the noisy pixel by trimmed mean 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 mean value of all the elements present in the selected window. This proposed algorithm shows better results than 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 algorithm is tested against different grayscale and color images and it gives better Peak Signal-to-Noise Ratio (PSNR).***

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. There are 2 varieties of impulse noise, they're salt and pepper noise and random valued noise. Salt and pepper noise corrupts the photographs wherever the corrupted image element takes either most or minimum grey level. Many nonlinear filters are projected for restoration of pictures contaminated by salt and pepper noise. Among these normal median filter has been established as reliable methodology to get rid of the salt and pepper noise while not damaging the sting details. However, the foremost downside of normal Median Filter (MF) is that the filter is effective solely at low noise densities [1].When the amplitude is over five hundredth the sting details of the first image won't be preserved by normal median filter. Adaptive Median Filter (AMF) [2] perform well at low noise densities. However at high noise densities the window size has got to be inflated which can cause blurring the image. In change median filter [3], [4] the choice is predicated on a pre-defined threshold value. The foremost downside of this methodology is that process a strong call is tough. Additionally these filters won't take under consideration the native options as a result of that detail and edges might not be recovered satisfactorily, particularly once the amplitude is high.

To counter the described downsides, Decision Based Algorithmic (DBA) is proposed [5]. In this, image is denoised by employing a 3x3 matrix. If the process component is 0 or 255 it's processed as an alternative it's left unchanged. At high noise density the norm are 0 or 255 that is noisy. In such case, neighborhood component is employed for replacement. This continual replacement of neighboring elements produces streaking result [6]. So to evade this downside, Decision Based Unsymmetrical Trimmed Median Filter (DBUTMF) is planned [7]. At higher noise densities, if the chosen window contains all 0's or 255's or each then, trimmed median value can't be obtained. Thus this algorithmic program doesn't offer higher results at terribly high noise density that's at 80% to 90%. The Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) algorithmic program removes this downside at high noise density and offers higher Peak signal to noise ratio (PSNR) values than the present algorithmic program. Now to improve the algorithm and to increase the image quality i.e. PSNR output of MDBUTMF is being passed through a Gaussian filter and outcome of the proposed algorithm is tremendous. The rest of the paper is structured as follows. A quick overview of unsymmertric 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 pictures are given in Section V. Finally conclusions are illustrated in Section VI.

2. Unsymmetric Trimmed Median Filter

The thought behind a trimmed channel is to reject the loud pixel from the chosen 3X3 window. Alpha Trimmed Mean Filtering (ATMF) is a symmetrical channel where the trimming is symmetric at either end. In this strategy, even the uncorrupted pixels are additionally cut. This prompts loss of picture points of interest, edges and obscuring of the picture. So as to conquer this downside, an Unsymmetric Trimmed Median Filter (UTMF) is proposed. In this UTMF, the chosen 3 X 3 window components are organized in either expanding or diminishing request. At that point the pixel values 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 uproarious 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 chose window. This system uproots clamor in preferred path over the ATMF.

3. Proposed Algorithm

The adapted decision based unsymmetrical trimmed mean filter cascaded with Gaussian (ADBUTMF) method forms the tainted pictures by first distinguishing the Salt and Pepper contamination. The handling pixel is checked whether it is uproarious or boisterous free. That is, if the transforming pixel lies in the middle of maximum and minimum gray level values then it is noise free pixel, it is left unaltered or intact. In the event that the handling pixel takes the most extreme or least gray level then it is boisterous pixel which is prepared by . The steps of the proposed algorithm are clarified as takes after.

4. Algorithm

Step 1: Select 2-D window of size 3X3. Assume that the pixel being processed is Xij
Step 2: If then is an uncorrupted pixel and its value is left unchanged. This is discussed in Case III) of Section IV.
Step 3: If more than one pixel is a corrupted pixel in the selected window then two cases are possible as given in Case i) and ii).

Case i): If the selected window contains all the elements as 0's and 255's. than increase the window size 4X4 and find non 0's and 255 value. and save tis value to replace Xij of the element of window.

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 Xij with the mean value.

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

5. Illustration of the Proposed Algorithm

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 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 then increase the window size and find out if any non 0's or 255 is present to replace the processing pixel:

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

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

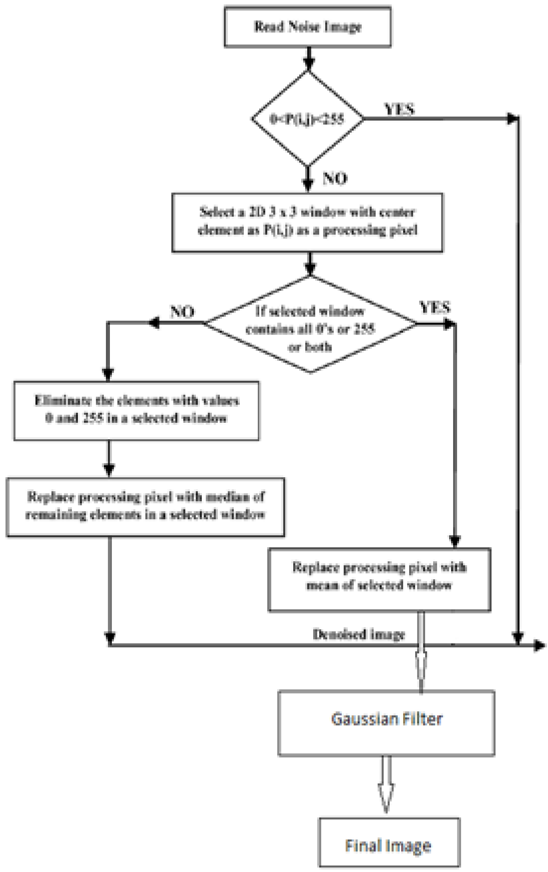

Figure 1: Flow Chart of Proposed Methodology

Since all the elements in the surrounding window is $\hat{Y}$ 0's and 255's.

If one takes the mean value it will be either 0 or 255 which is again noisy. To solve this problem, increase the size of window i.e. 4X4 and check for the value which is non zero and 255 and replace the processing pixel by that value or if the expanded window is also noisy than calculate the mean of the selected 3X3 window and the processing pixel is 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 pixels that adds salt (i.e., 255 pixel value) 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 further processing. For example, if the processing pixel is 90 then it is noise free pixel:

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

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

6. 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 as defined in (1).

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

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

where MSE stands for mean square error, MXN is size of the image, Y represents the original image, denotes the denoised image.

Table 1: PSNR of proposed and existing algorithm at 10% to 90% noise density

Noise in %	PSNR in DB						
	MF	AMF	PSMF	DBA	MDBA	MDBUTMF	CASCADED
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

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 above. From the Tables above, it is observed that the performance of the Cascaded Gaussian 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 Fig. below. In this figure, 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 Cascaded Gaussian. The proposed algorithm is tested against images namely Baboon and Lena. The images are corrupted by with upto 90% “Salt and Pepper” noise. The PSNR values of these images using different algorithms are given in Figure below. From the figure, it can be made out that the Cascaded Gaussian provides better PSNR values irrespective of the nature of the input image.

The Cascaded Gaussian is also used to process the color images that are corrupted by salt and pepper noise. The color image taken into account is Baboon. In Fig. below, the first column represents the processed image using MF at 80% and 90% noise Densities. Subsequent columns represent the processed images for PSMF, DBA, MDBA and MDBUTMF. From the figure, it is possible to observe that the quality of the restored image using proposed algorithm is better than the quality of the restored image using existing algorithms.

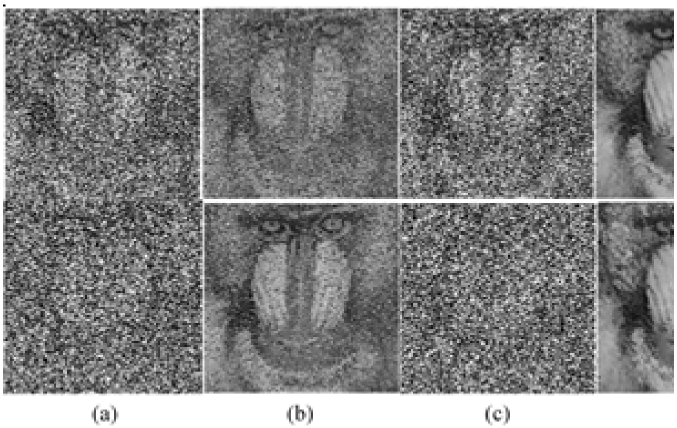

Figure 2: Results of different algorithms for Baboon image. (a) Output of MF. (b) Output of AMF. (c) Output of PSMF. (d) Output of DBA. (e) Output of MDBA. (f) Output of MDBUTMF (g) Output of Cascaded Gaussian. Row 1 and Row 2 show processed results of various algorithms for image corrupted by 80% and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

Figure 3: Original Image

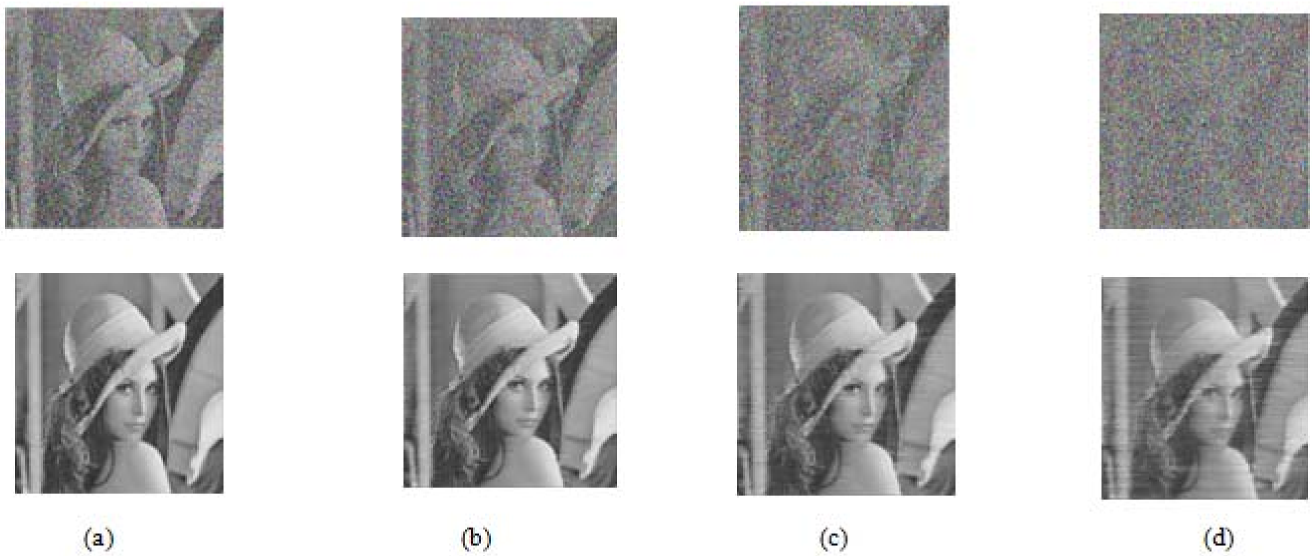

Figure 4: Result of the Algorithm on Lena Image with different Noise inputs (a) 60% (b) 70% (c) 80% (d) 90%

7. Conclusion

The aim of this article was to propose a better algorithmic approach towards the image retrieval from an image induced with high density Salt and Pepper noise. The proposed Cascade Gaussian Algorithmic approach has proven efficient and useful for this task. The algorithm was compared with the existing methods like MDBUTMF, MF, AMF and others and hence it was found that its performance was better in all the available approach 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 effective for High density Salt & Pepper noise removal. Future experiments can be done on colored or RGB image with the same algorithm or better approach.

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