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Implementation of efficient Image Enhancement Factor using Modified Decision Based Unsymmetric Trimmed Median Filter

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Abstract:

In this paper, we are proposing an approach to minimize very high density salt and pepper noise through modified decision based unsymmetrical trimmed median filter. The proposed filter replaces the noisy pixel by trimmed median value when some of the elements with values 0's and 255's are presented in the selected window. If all the pixel values in the selected window are o's and 255's then the noisy pixels area replaced by mean value of the all the elements presented in the selected window. The proposed algorithm exhibits better image quality than the median filter, adaptive median filter, decision based algorithm, modified decision based algorithm, and progressive switched median filter. The proposed algorithm tested against different gray-scale and color images giving better peak Signal-to-Noise Ratio (PSNR) and Image Enhancement Factor (IEF) at different noise densities.

1.Introduction:

Salt and pepper noise can be caused by channel transmission errors, malfunctioning pixels in camera sensors, faulty memory locations in hardware, sharp and sudden disturbances in the image. This noise can corrupt the images where the corrupted pixels take either maximum or minimum gray level. The appearance of noise is as white and black dots superimposed on the image and hence the name salt and pepper noise. This noise occurred as white pixel in a black field or a black pixel in a white field. In the presence of salt and pepper noise information in the image may be get corrupted. Therefore, removal of this type of noise is critical for the extraction of reliable and accurate information from a digital image. The main objective of salt & pepper noise removal is that it removes the noise from the image by preserving the other image details. The linear filters used for impulse noise removal works much better for low noise density as compared to high noise density. For high noise density, the output images are blurred and edges are not preserved accurately by the linear filters. Therefore the non-linear filters have been used to provide better filtering performance in terms of impulse noise removal and preservation of other details of the images.

Median filters have attracted very much attention due to their simplicity and information preservation capabilities. The main drawback of the median filter is that it also modifies non noisy pixels thus removing some fine details of the image. Therefore it is only suitable for very low level noise density. High noise density it shows the blurring for the larger template sizes and not able to suppress the noise completely for smaller template size.

Adaptive Median Filter (AMF) [2] performs well at low noise densities. But at high noise densities the window size has to be increased which may lead to blurring the image. In switching median filter [3], [4] the decision is based on a pre-defined threshold value. The major drawback of this method is that defining a robust decision is difficult. Also these filters will not take into account the local features as a result of which details and edges may not be recovered satisfactorily, especially when the noise level is high.

To overcome the above drawback, Decision Based Algorithm (DBA) is proposed [5]. In this, image is denoised by using a 3x3 Window. If the processing pixel value is 0 or 255 it is processed or else it is left unchanged. At high noise density the median value will be 0 or 255 which is noisy. In such case, neigh- boring pixel is used for replacement. This repeated replacement of neighboring pixel produces streaking effect [6]. In order to avoid this drawback, Decision Based Unsymmetrical Trimmed Median Filter (DBUTMF) is proposed [7]. At high noise densities, if the selected window contains all 0's or 255's or both then, trimmed median value cannot be obtained. So this algorithm does not give better results at very high noise density that is at 80% to 90%. The proposed Modified Decision Based Un- symmetric Trimmed Median Filter (MDBUTMF) algorithm re- moves this drawback at high noise density and gives better Peak Signal-to-Noise Ratio (PSNR) and Image Enhancement Factor (IEF) values than the existing algorithm.

The rest of the paper is structured as follows. A brief introduction of unsymmetrical trimmed median filter is given in Section2

Section 3 describes about the proposed algorithm &different cases of proposed algorithm.The detailed description of the proposed algorithm with an example is presented in Section 4 Simulation results with different images are presented in Section 5. Finally conclusions are in Section 6.

2.Unsymmetrical trimmed median filter:

The idea behind a trimmed filter is to reject the noisy pixel from the selected 3x 3window.Alpha Trimmed Mean Filtering (ATMF) is a symmetrical filter where the trimming is symmetric at either end. In this procedure, even the uncorrupted pixels are also trimmed. This leads to loss of image details and blurring of the image. In order to overcome this drawback, an Unsymmetrical Trimmed Median Filter (UTMF) is proposed. In this UTMF, the selected 3 x3 window elements are arranged in either increasing or decreasing order. Then the pixel values 0's and 255's in the image (i.e., the pixel values responsible for the salt and pepper noise) are removed from the image. Then the median value of the remaining pixels is taken. This median value is used to replace the noisy pixel. This filter is called trimmed median filter because the pixel values 0's and 255's are removed from the selected window. This procedure removes noise in better way than the ATMF.

3.Proposed algorithm:

Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) algorithm processes the Corrupted images by first detecting the impulse noise. The Processing pixel is checked whether it is noisy or noisy free. That is, if the processing pixel lies between maximum and minimum gray level values then it is noise free pixel, it is left unchanged. If the processing pixel takes the maximum or minimum gray level then it is noisy pixel which is processed by MDBUTMF. The steps of the MDBUTMF Each and every pixel of the image is checked for the presence of salt and pepper noise.

Algorithm Description

Step 1: Select 2-D window of size 3x 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 4.

Step 3: If $P_{ij}=0$ or $P_{ij}=255$ then is a corrupted pixel 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. Then replace With the mean 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 median value of the remaining elements. Replace with the median 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 4.

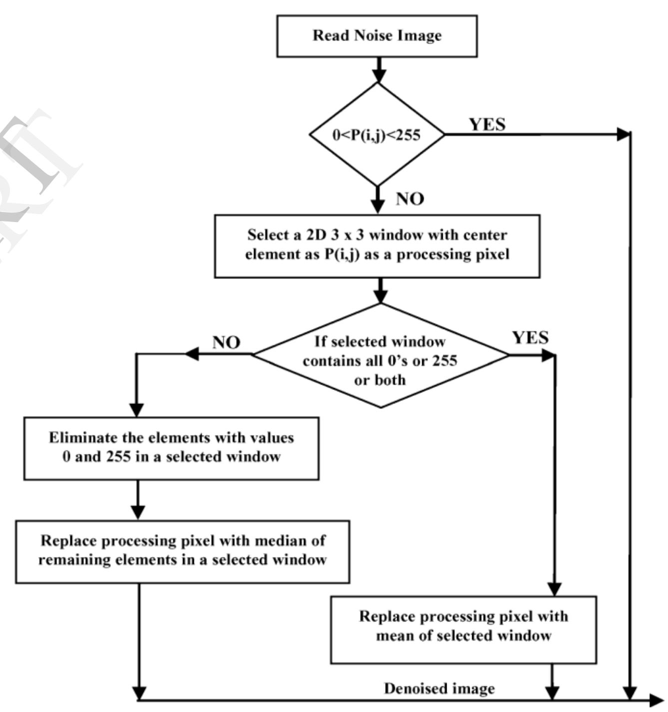


Fig. 1. Flow chart of MDBUTMF.

4.Illustration of MDBUTMF Algorithm:

Each and every pixel of the image is checked for the presence of salt and pepper noise. Different cases are illustrated in this Section. If the processing pixel is noisy and all other pixel values are either 0's or 255's is illustrated 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 neighbouring pixel values contains all pixels that adds salt and pepper noise to the image:

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

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

Since all the elements surrounding P_{ij} 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, the mean of the selected window is found and the processing pixel is replaced by the mean value. Here the mean value is 170. Replace the processing pixel by 170.

Case ii): If the selected window contains salt/pepper noise as processing pixel (i.e., 255/0 pixel value) and neighbouring pixel values contains some pixels that adds salt and pepper noise to the image:

$$\begin{bmatrix} 78 & 98 & 0 \\ 120 & \langle 0 \rangle & 255 \\ 97 & 255 & 73 \end{bmatrix}$$

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

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 median value is 90. Hence replace the processing pixel P_{ij} by 90.

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 ,i.e.,(P_{ij})

Since "90" is a noise free pixel it does not require further processing.

5. Simulation Results:

The performance of the proposed algorithm is tested with different grayscale and colour images. The noise density (intensity) is varied from 10% to 90%. Denoising performances are quantitatively measured by the PSNR and IEF as defined in (1) and (3), respectively:

$$\text{PSNR IN dB} = 10 \log_{10}(255^2/\text{MSE})$$

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

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

Where, MXN size of the image
Y=original image
η = noise image
Ŷ= Denoise image

The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers , or to provide better input for other automated image processing techniques.

Image enhancement techniques can be divided into two broad categories: Spatial domain methods, which operates directly on pixels. Frequency domain methods , which operate on the Fourier transform of an image.

The ratio between the maximum possible power of a signal and power of a corrupting noise that effects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale.

Table 1

COMPARISON OF PSNR VALUES OF DIFFERENT ALGORITHMS FOR LENA IMAGE AT DIFFERENT NOISE DENSITIES

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

Table 2

COMPARISON OF IEF VALUES OF DIFFERENT ALGORITHMS FOR LENA IMAGE AT DIFFERENT NOISE DENSITIES

Noise Density in %	IEF					
	MF	AMF	PSMF	DBA	MDBA	MDBUT
10	10.36	23.20	171.63	390.67	422.58	648.9
20	28.17	37.76	207.31	358.91	377.42	568.4
30	30.02	42.57	190.92	322.89	324.74	590.8
40	23.12	40.98	143.49	268.49	275.24	424.1
50	11.72	36.11	62.98	208.77	217.18	345.1
60	6.73	25.21	6.61	190.70	175.89	261.6
70	3.31	7.89	3.28	128.58	129.65	171.6
80	2.00	2.91	1.98	67.42	73.24	101.7
90	1.37	1.31	1.37	33.85	33.33	34.2

Table 3

COMPARISON OF PSNR VALUES OF DIFFERENT TEST IMAGES AT NOISE DENSITY OF 70%

Test images	PSNR in dB					
	MF	AMF	PSMF	DBA	MDBA	MDBUT
Cameraman	9.46	13.93	9.47	20.84	19.97	22.5
Lena	9.93	15.25	9.84	22.64	22.47	24.3
Baboon	10.11	14.86	10.05	22.35	20.54	23.8

Fig. 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. Row 1 and Row 2 show processed results of various algorithms for image corrupted by 80% and 90% noise densities, respectively

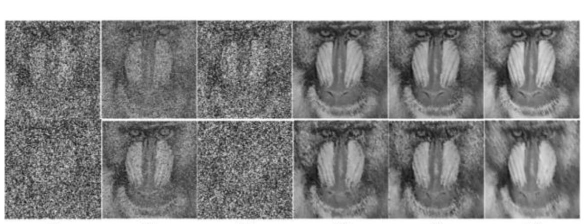


Fig. 3. Comparison graph of PSNR and IEF at different noise densities for Baboon image

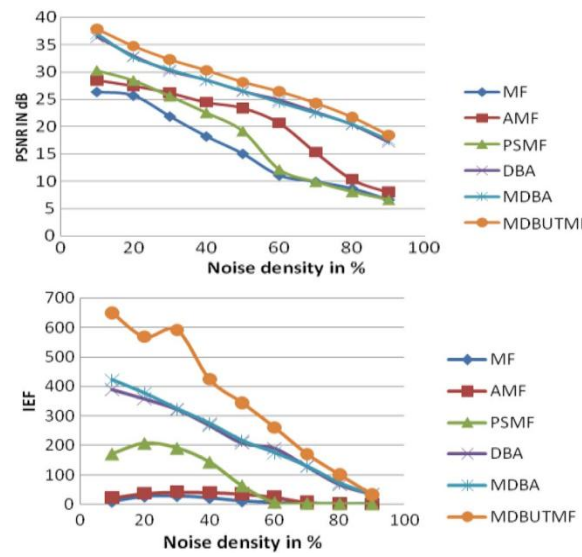
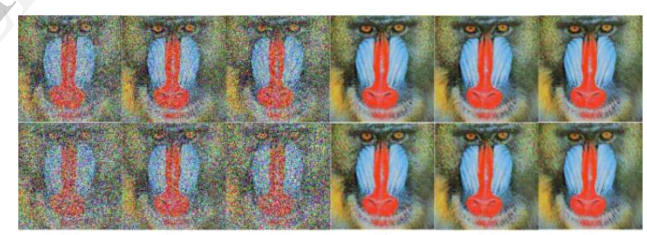


Fig. 4. Results of different algorithms for color Baboon image. (a) Output of MF. (b) Output of AMF. (c) Output of PSMF. (d) Output of DBA. (e) Output of MDBA. (f) Output of MDBUTMF. Rows 1 and 2 show processed results of various algorithms for color image corrupted by 70% and 80% noise densities, respectively



6.Conclusion

In this letter, a new algorithm (MDBUTMF) is proposed which gives better performance in comparison with MF, AMF and other existing noise removal algorithms in terms of PSNR and IEF. The performance of the algorithm has been tested at low, medium and high noise densities on both gray-scale and color images. Even at high noise density levels the MDBUTMF gives better results in comparison with other existing algorithms. Both visual and quantitative results are demonstrated. The proposed algorithm is effective for salt and pepper noise removal in images at high noise densities.

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