Removal of High Density Salt and Pepper Noise through Modified Decision based Un Symmetric Trimmed Median Filter

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Abstract: ***It is important to remove or minimize the degradations, noises in valuable ancient blurred color images. The traditional available filtering methodologies are applicable for fixed window dimensions only these are not applicable for varying scale images. In our project we propose a new technique for digital image restoration, in this the noise free and noisy pixels are classified based on empirical multiple threshold values. Then the median filtering technique is applied. So that noise free pixels are getting preserved and only noisy pixels get restored. In this project, a novel decision-based filter, called the multiple thresholds switching (MTS) filter, is proposed to restore images corrupted by salt-pepper impulse noise. The filter is based on a detection-estimation strategy. The impulse detection algorithm is used before the filtering process, and therefore only the noise-corrupted pixels are replaced with the estimated central noise-free ordered mean value in the current filter window. The new impulse detector, which uses multiple thresholds with multiple neighborhood information of the signal in the filter window, is very precise, while avoiding an undue increase in computational complexity. For impulse noise suppression without smearing fine details and edges in the image, extensive experimental results demonstrate that our scheme performs significantly better than many existing, well-accepted decision-based methods. The performance of our proposed algorithm will be analyzed based PSNR and MSE values.***

Keywords: Peak Signal to Noise Ratio (PSNR), Mean square Error (MSE)

1. Introduction

In image processing it is usually necessary to perform high degree of noise reduction in an image before performing higher-level processing steps, such as edge detection. The median filter is a non-linear digital filtering technique, often used to digital filtering technique, often used to remove noise from images or other signals. The idea is to examine a sample of the input and decide if it is representative of the signal. This is performed using a window consisting of an odd number of samples. The values in the window are sorted into numerical order; the median value, the sample in the center of the window, is selected as the output. The oldest sample is discarded, a new sample acquired, and the calculation repeats. Median filtering is a common step in image processing. It is particularly useful to reduce speckle noise and salt and pepper noise. Its edge-preserving nature makes edge blurring is undesirable.

Image synthesis is the process of creating new images from some form of image description. The kinds of images that are typically synthesized include:

Test Patterns: Scenes with simple two dimensional geometric shapes.

Image Noise: Images containing random pixel values usually generated from specific parameterized distributions.

Computer Graphics: Scenes or images based on geometric shape descriptions. Often the models are three dimensional, but may also be two dimensional.

Synthetic images are often used to verify the correctness of operators by applying them to known images. They are also often used for teaching purposes, as the operator output on such images is generally `clean', whereas noise and uncontrollable pixel distributions in real images make it harder to demonstrate unambiguous results. The images could be binary, grey level or color. Impulse noise in images is present due to bit errors in transmission or introduced during the signal acquisition stage. There are two types of impulse noise, they are salt and pepper noise and random valued noise. Salt and pepper noise can corrupt the images where the corrupted pixel takes either maximum or minimum gray level. Several nonlinear filters have been proposed for restoration of images contaminated by salt and pepper noise. Among these standard median filter has been established as reliable method to remove the salt and pepper noise without damaging the edge details. However, the major drawback of Standard Median Filter (MF) is that the filter is effective only at low noise densities [1].When the noise level is over 50% the edge details of the original image will not be preserved by standard median filter.

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 de noised by using a 3*3window. 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, neighboring pixel is used for replacement. This repeated replacement of neighboring pixel produces streaking effect.

In order to avoid this drawback, Decision Based Un symmetric 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 removes 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 Un symmetric trimmed median filter is given in Section II. Section III describes about the proposed algorithm and different cases of proposed algorithm.

The detailed description of the proposed algorithm with an example is presented in Section IV. Simulation results with different images are presented. Finally conclusions are drawn.

2. Un Symmetric Trimmed Median Filter

The idea behind a trimmed filter is to reject the noisy pixel from the selected 3* 3 window. 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 Un symmetric Trimmed Median Filter (UTMF) is proposed. In this UTMF, the selected 3* 3 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

The proposed Modified Decision Based Un symmetric 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 are elucidated as follows

ALGORITHM

Step 1: Select 2-D window of size 3 3. Assume that the pixel being processed is pij.

Step 2: If then is an uncorrupted pixel and its value is left unchanged. This is illustrated in Case iii) of Section IV.

Step 3: If or 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 IV.

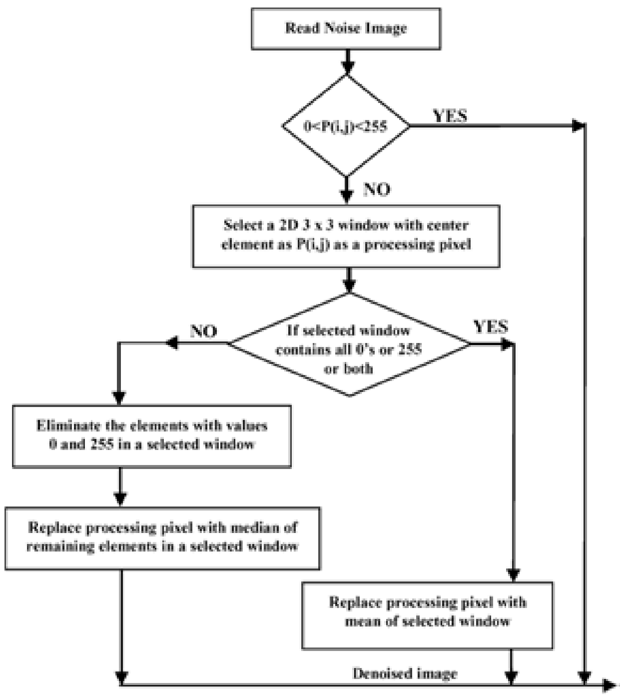

Figure 1: Flow chart of MDBUTMF

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 neighboring pixel values contains all pixels that adds salt and pepper noise to the image:

0	255	0
0	255	255
255	0	255

Since all the elements surrounding 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 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: 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 median value is 90.

78	90	0
120	0	255
97	255	73

Hence replace the processing pixel 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: where "90" is processing pixel, i.e., .Since "90" is a noise free pixel it does not require further processing.

43	67	70
55	90	79
85	81	66

An intelligent hardware structure of a median filter suitable for impulse noise suppression for gray-scale images is presented for the first time. The function of the proposed circuit is to detect first the existence of noise in the image window and apply the corresponding median filter only when necessary. The main advantage of this adaptive approach is that the blurring of the image in process is avoided and the integrity of edge and detail information is preserved.

The proposed digital hardware structure is capable of processing gray-scale images of 8-bit resolution and performs both positive and negative impulse noise removal. The architecture chosen is based on a sequence of four basic functional pipelined stages and parallel processing is used within each stage.

The proposed structure was implemented using field-programmable gate arrays (FPGAs), which offer an attractive combination of low-cost, high-performance, and apparent flexibility.

5. Simulation Results

The performance of the proposed algorithm is tested with different grayscale and color images. The noise density (intensity)

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

It is varied from 10% to 90%. Denoising performances are quantitatively measured by the PSNR and IEF as defined in (1) and (3), respectively:

PSNR in dB = 10log 10(255/MSE) (1)

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	MDBUTMF
10	10.36	23.20	171.63	390.67	422.58	648.98
20	28.17	37.76	207.31	358.91	377.42	568.43
30	30.02	42.57	190.92	322.89	324.74	590.83
40	23.12	40.98	143.49	268.49	275.24	424.18
50	11.72	36.11	62.98	208.77	217.18	345.13
60	6.73	25.21	6.61	190.70	175.89	261.66
70	3.31	7.89	3.28	128.58	129.65	171.69
80	2.00	2.91	1.98	67.42	73.24	101.72
90	1.37	1.31	1.37	33.85	33.33	34.23

where MSE stands for mean square error, IEF stands for image enhancement factor, is size of the image, Y represents the original image, denotes the de noised image, represents the noisy image.

The PSNR and IEF 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 I and Table II. From the Tables I and II, it is observed that the performance of the proposed algorithm (MDBUTMF) is better than the existing algorithms at both low and high noise densities. A plot of PSNR and IEF against noise densities for Lena image is shown in Fig. 2.

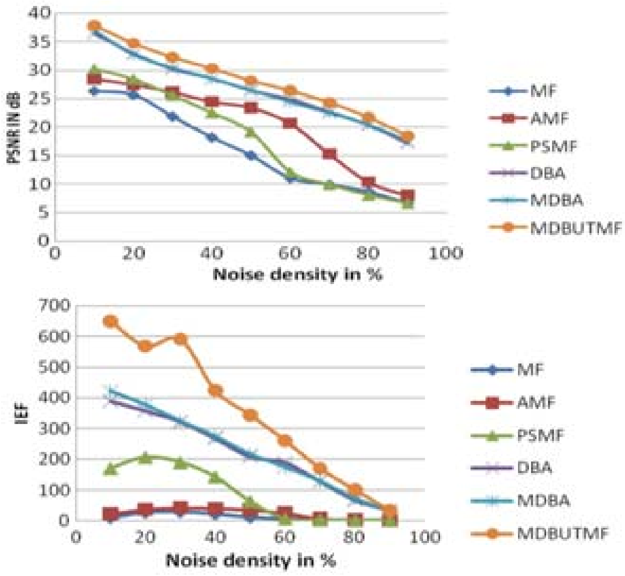

Figure 2: Comparison graph of PSNR and IEF at different noise densities for Lena image

Test images	PSNR in dB					
	MF	AMF	PSMF	DBA	MDBA	MDBUTMF
Cameraman	9.46	13.93	9.47	20.84	19.97	22.52
Lena	9.93	15.25	9.84	22.64	22.47	24.30
Baboon	10.11	14.86	10.05	22.35	20.54	23.80

Figure 3: Comparison of PSNR Values of Different Test Images at Noise Density of 70%∑

The qualitative analysis of the proposed algorithm against the existing algorithms at different noise densities for Baboon image is shown in Fig. 3. 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 and MDBUTMF. The proposed algorithm is tested against images namely Cameraman, Baboon and Lena. The images are corrupted by 70% "Salt and Pepper" noise. The PSNR values of these images using different algorithms are given in Table III. From the table, it is clear that the MDBUTMF gives better PSNR values irrespective of the nature of the input image. The MDBUTMF 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. 4, 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.

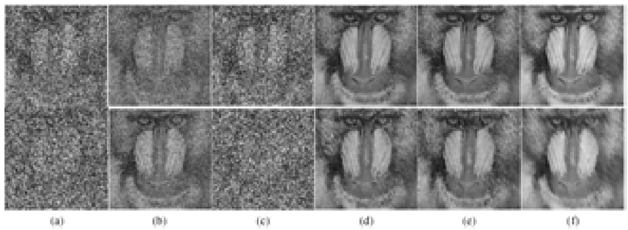

Figure 4: Results of different algorithms for Baboon image. (a) Output of MF. (b) Output of AMF. (c) Output of PSMF. (d) Output of DBA. (e) Output of MDBA.(f) Output of MDBUTMF. Row 1 and Row 2 show processed results of various algorithms for image corrupted by 80% and 90% noise densities, respectively.

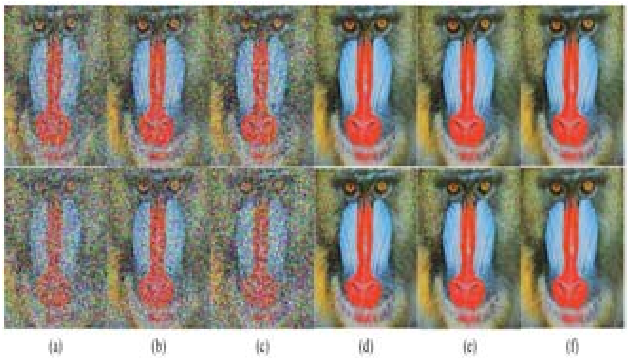

Figure 5: Results of different algorithms for color Baboon image. (a) Output of MF. (b) Output of AMF. (c) Output of PSMF. (d) Output of DBA. (e) Output of MDBA. (f) Output of MDBUTMF. Rows 1 and 2 show processed results of various algorithms for color image corrupted by 70% and 80% noise densities, respectively.

6. Conclusion

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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