A Modified Algorithm for the Restoration of Digital Images and Videos by Removing High Density Salt and Pepper Noise

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Abstract

In the Transmission of Images and Videos over channels are corrupted by impulse noises due to faulty communication systems. Removal of noises from the images and video sequence is a critical issue for the restoring without loss of original information. This paper proposes a Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTM) to remove salt and pepper noise from corrupted images and videos. Different gray scale, color images and videos have been tested by using the proposed algorithm and found to produce better PSNR and MSE values than existed algorithms.

Key Words -- *Median Filter, Salt and Pepper Noise, Unsymmetrical Trimmed Median Filter, Peak Signal to Noise Ratio (**PSNR**), Mean Square Error (**MSE**).*

1. Introduction

Generally 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 pixel takes either maximum or minimum gray level. For removal of impulse noises the best-known and most widely used non-linear digital filters. There are several nonlinear filters have been proposed for the restoration of images corrupted by salt and pepper noise those are illustrated in section 2.

The rest of the paper is structured as follows. A brief introduction of unsymmertric trimmed median filter is given in Section 3. Section 4 describes about the proposed algorithm and different cases of proposed algorithm. Simulation results with different images are presented in Section 5. Finally conclusions are drawn in Section 6.

2. Existed Algorithms

The existed algorithms which were used for the comparison with proposed algorithms are described below.

Standard Median Filter (SMF) 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 is that the filter is effective only at low noise densities. Standard median filter will not preserved the edge details of the original image when the noise level is over 50%.

Adaptive Median Filter (AMF) 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 Decision Based Algorithm (DBA) the image is denoised by using a 3×3 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, neighboring pixel is used for replacement. This repeated replacement of neighboring pixel produces streaking effect.

By using Tolerance Based Selective Arithmetic Mean Filtering Technique (TSAMFT) salt and pepper noise removed by arithmetic mean filtering. In this the corrupted pixel replaced by tolerance value that is a threshold value. But this algorithm doesn't performs well when noise density more than 70%.

Hence the proposed algorithm Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) overcomes the drawbacks and removes noise at high density with a better Peak Signal-to-Noise Ratio (PSNR) and Mean Square Error (MSE) values than the existing algorithm.

3. UNSYMMETRIC TRIMMED MEDIAN FILTER

The main principle of a trimmed filter is to reject the noisy pixel from the selected 3×3window. The selected 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. This algorithm is applicable for the gray scale, color images and videos. It can be applied at different stages in images when compared with videos are shown in the following block diagrams.

Block Diagram

For Image:

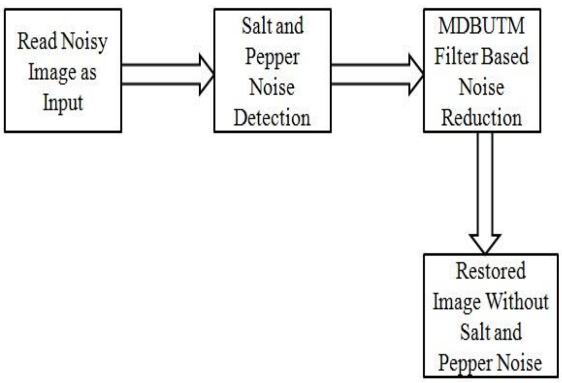

Fig.3.1: Removing of Noise in Images

For Videos:

Before applying this algorithm to videos first the video can be divided into frames and after that corrupted frame is detected by the filter. The noise in the frame is removed by the proposed algorithm and restores the video without loss of original information.

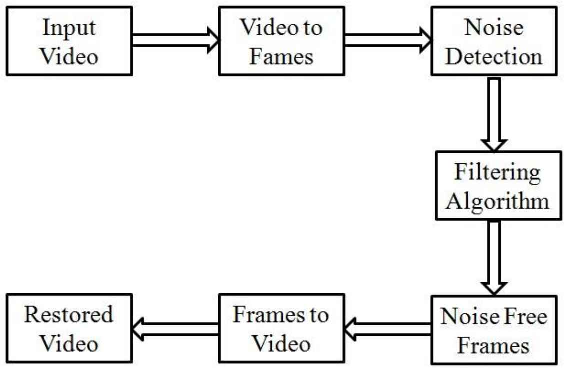

Fig.3.2: Removing of Noise in videos

4. PROPOSED ALGORITHM

The proposed 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 are elucidated as follows.

ALGORITHM

STEP 1: Select 2-D window of size 3× 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.

STEP 3: If $P_{ij}=0$ or $P_{ij}=255$ then P_{ij} 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 P_{ij} 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 P_{ij} 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.4.1.

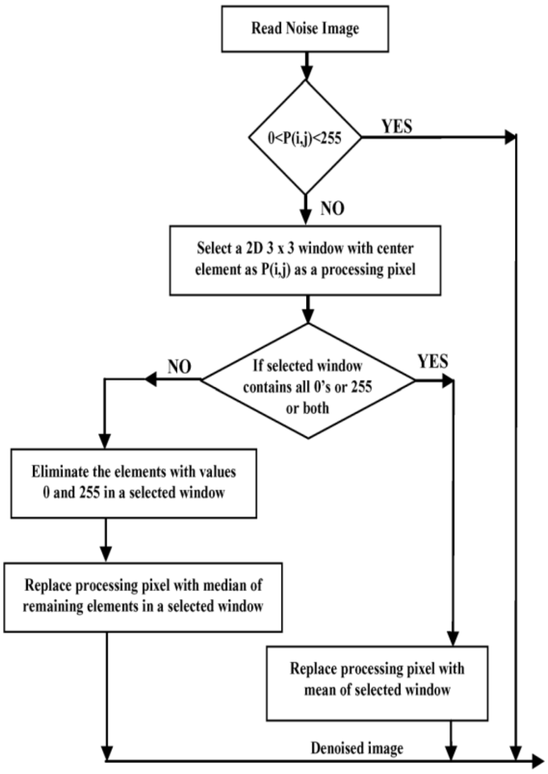

Fig.4.1. Flow chart of MDBUTMF.

5. SIMULATION RESUTS

The performance of the proposed algorithm is tested with different grayscale color images and videos at different noise levels. The performances are quantitatively measured by the PSNR (Peak to Signal Noise Ratio), and MSE (Mean Square Error) are defined as

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

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

Where M×N represents the size of the image, Y represents the original image, $\hat{Y}$ denotes the denoised image. The PSNR and MSE values of the proposed algorithm are compared against the existing algorithms by varying the noise levels and are shown in Table I and Table II.

TABLE I

Comparison of PSNR values of different algorithms for Cameraman image at different noise densities

Noise Level	PSNR in dB				
	SMF	AMF	TSAMFT	DBA	Proposed Algorithm MDBUTM
10%	27.1726	31.3968	28.0861	30.036	44.8945
20%	27.0707	31.308	28.0284	29.4063	42.0733
30%	26.9284	30.9122	28.0029	28.325	39.8537
40%	26.8471	30.9068	27.9262	27.8668	38.2225
50%	26.7028	30.7544	27.8639	27.2774	37.7499
60%	26.6352	30.6876	27.8253	26.6677	36.3484
70%	26.4636	30.6204	27.7589	26.6869	35.7049
80%	26.3307	30.2195	27.7137	26.147	35.1215
90%	26.1102	30.1374	27.6699	25.8079	34.5541

TABLE II

Comparison of MSE values of different algorithms for Cameraman image at different noise densities

Noise Level	MSE				
	SMF	AMF	TSAMFT	DBA	Proposed Algorithm MDBUTM
10%	125.668	47.5113	101.828	64.9944	2.12338
20%	128.65	48.4935	103.191	75.1366	4.065834
30%	132.936	53.1198	103.799	96.3783	6.77818
40%	135.446	53.186	105.648	107.103	9.86807
50%	140.024	55.0853	107.175	122.67	11.0026
60%	142.219	55.94	108.131	141.159	15.193
70%	147.953	56.8126	109.798	140.537	17.6193
80%	152.549	62.306	110.947	159.139	20.1524
90%	160.493	63.4956	112.071	172.065	22.9654

From the Tables I and II, it is observed that the performance of the proposed algorithm is better than the existing algorithms at both low and high noise densities. The proposed algorithm is tested against images namely Baboon, Lena, Flower, Boat and Cameraman. The images are corrupted by 80% "Salt and Pepper" noise. The PSNR values of these images using different algorithms are given in Table III.

TABLE III: Comparison of PSNR values of different test images at noise density of 80%

Test Images	PSNR in dB				
	SMF	AMF	TSAMFT	DBA	Proposed Algorithm MDBUTM
Baboon	8.50574	9.79416	10.0305	8.89834	11.5265
Lena	33.5473	37.3632	38.9402	32.7063	41.4576
Flower	11.2956	10.663	12.3568	9.56251	11.6476
Boat	27.84	32.63	32	28.70	41.49
Cameraman	26.3307	30.2195	27.7137	26.147	35.1215

From the table, it is clear that the MDBUTMF gives better PSNR values irrespective of the nature of the input image. The qualitative analysis of the proposed algorithm against the existing algorithms at different noise densities for Lena color image is shown in Fig.5.1 and for the gray scale images is shown in Fig.5.2.

(a) (b)

(c) (d)

(e) (f)

Fig.5.1. Results of different algorithms for Lena color image. (a) Processing Image with salt and pepper noise of density80%. (b) Output of SMF. (c) Output of AMF. (d) Output of TSAMFT. (e) Output of DBA. (f) Output of MDBUTMF.

(a) (b)

(c) (d)

(e) (f)

Fig.5.2. Results of different algorithms for Baboon Gray Scale image. (a) Processing Image with salt and pepper noise of density80%. (b) Output of SMF (c) Output of AMF (d) Output of TSAMFT (e) Output of DBA. (f) Output of MDBUTMF.

This algorithm can applied to videos also gives better PSNR and MSE values than existed algorithms.

6. CONCLUSION

In this paper, a new algorithm (MDBUTMF) is proposed which gives better performance in comparison with SMF, 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 though this algorithm can applied to video sequence for the restoration of original by removing high density salt and pepper noise. Both visual and quantitative results are demonstrated. The proposed algorithm is effective for salt and pepper noise removal in images and videos at high noise densities.

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