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Removal Of High Density Salt & Pepper Noise In Quick Transient Or Faulty Switching Images

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Abstract

A modified decision based unsymmetrical trimmed median filter algorithm for the restoration of gray scale, and color images that are highly corrupted by salt and pepper noise is proposed in this paper. The proposed algorithm replaces the noisy pixel by trimmed median 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 hen 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), ModifiedDecision Based Algorithm (MDBA), and Progressive Switched Median Filter (PSMF). The proposed algorithm is tested against different grayscale and color images and it gives better Peak Signal-to-Noise Ratio (PSNR) and Image Enhancement Factor.

Keywords: ***Median filter, Midpoint filter, trimmed filter,***
shear sort.

I. INTRODUCTION

Impulse noise in images is present due to bit errors intransmission 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] perform 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 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 3*3 window Consequently, the effective removal of impulse often leads to images with blurred and distorted features. Ideally, the filtering should be applied only to corrupted pixels while leaving uncorrupted pixels intact. Applying median filter unconditionally across the entire image as practiced in the conventional schemes would inevitably alter the intensities and remove the signal details of uncorrupted pixels. Therefore, a noise-detection process to discriminate between uncorrupted pixels and the corrupted pixels prior to applying nonlinear filtering is highly desirable.

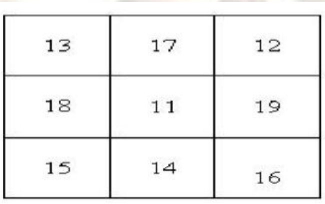
Adaptive Median is a “decision-based” or switching”filter that first identifies possible noisy pixels and then replaces them using the median filter or its variants, while leaving all other pixels unchanged. This filter is good at detecting noise even at a high noise level. The adaptive structure of this filter ensures that most of the impulse noises are detected even at a high noise level provided that the window size is large enough. The performance of AMFis good at lower noise density levels, due to the fact that there are only fewer corrupted pixels that are replaced by the median values [6], [7], [8]. At higher noise densities, the number of replacements of corrupted pixel increases considerably; increasing window size will provide better noise removal performance; however, the corrupted pixel values and replaced median pixel values are less correlated. As a consequence the edges are smeared significantly.

Recently the DBA processes the corrupted image by first detecting the impulse noise. the detection of noisy and noise free pixels is decided by checking whether the value of a processed pixel lies between the maximum and minimum values in the dynamic range(0,255).if the value of the pixel is within the range then it is an uncorrupted pixel and left unchanged..if the value does not in the range then it is a noisy pixel. This provides higher correlation which leads to better edge preservation. The main drawback of DBA is that streaking occurs at higher noise densities due to replacement with the neighborhood pixel values.Hence, details and edges are not recovered satisfactorily, especially when the noise level is high.

SORTING ALGORITHM

Shear Sorting Algorithm

Sorting is the most important operation used to find the median of a window. There are various sorting algorithms such as binary sort, bubble sort, merge sort, quick sort etc. In the proposed algorithm, shear sorting technique is used since it is based on parallel architecture. In practice the parallel architectures help to reduce the number of logic cells required for its implementation. The illustration of shear sorting is shown in Figure. 1 - 4. In the odd phases (1,3,5) even rows are sorted in descending order and rows are sorted out in ascending order. In the even phases columns are sorted out independently in ascending order.



Figuer.1.Original matrix before sorting

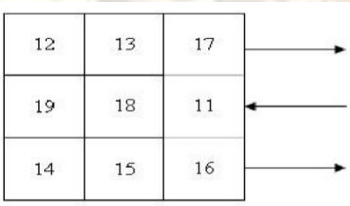


Figure.2.Step 1- Row sorting

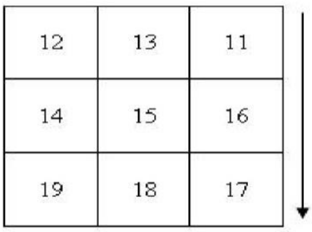


Figure.3.Step 3- Column sorting

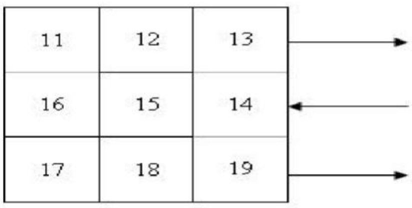


Figure.4. Step 4- Row sorting

Modified Shear Sorting Algorithm:

In order to improve the computational efficiency shear sorting algorithm is modified as follows:
Step 1) All the three rows of the window are arranged in ascending order.
Step 2) Then all the columns are arranged in ascending order.
Step 3) The right diagonal of the window is now arranged in ascending order.

In this case, the first element of window is the minimum value, last element of the window is the maximum value and middle element of window is the median value. After the third stage of sorting itself the median value is obtained even though all the elements are not arranged in ascending order. The illustration of sorting algorithm is shown in the table containing the comparison of the various sorting techniques.

Table I Comparison of the various sorting techniques

Sorting techniques	No of comparisons required to compute median 3x3 window	
	Best case	Worst case
Bubble sort	36	36
Shear sort	18	36
Modified shear sort	21	21

III. DECISION BASED UN SYMMETRIC TRIMMED MEDIAN FILTER (DBUTM)

Decision Based Algorithm (DBA) is a recently proposed algorithm to remove salt and pepper noise. In DBA each pixel is processed for de noising using a 3 X 3 window. During processing if a pixel is '0' or '255' then it is processed else it is left unchanged. In DBA the corrupted pixel is replaced by the median of the window. At higher noise densities the median itself will be noisy, and, the processing pixel will be replaced by the neighborhood-processed pixel. This repeated replacement of neighborhood pixels produces streaking effect. In DBUTM, the corrupted pixels are identified and processed. The DBUTM algorithm checks whether the left and right extreme values of the sorted array obtained from the 3x3 window are impulse values. The corrupted processing pixel is replaced by a median value of the pixels in the 3 X 3 window after trimming impulse values. The corrupted pixel is replaced by the median of the resulting array.

A. Algorithm

The algorithm for DBUTM is as follows:
Step 1: A 2-D window 'S_{xy}' of size 3x3 is selected.

Step 2: The pixel values in the window are sorted in ascending order, and stored in a 1-D array.
Step 3: If the pixel value in the array is either '0' or '255', the corresponding pixel values are trimmed (eliminated), and the median of remaining values is calculated.
Step 4: The pixel being processed is replaced by the median value calculated.
Move the window by one step, and repeat from step 2 to step 4. The above steps are repeated, until the processing is completed for entire image.

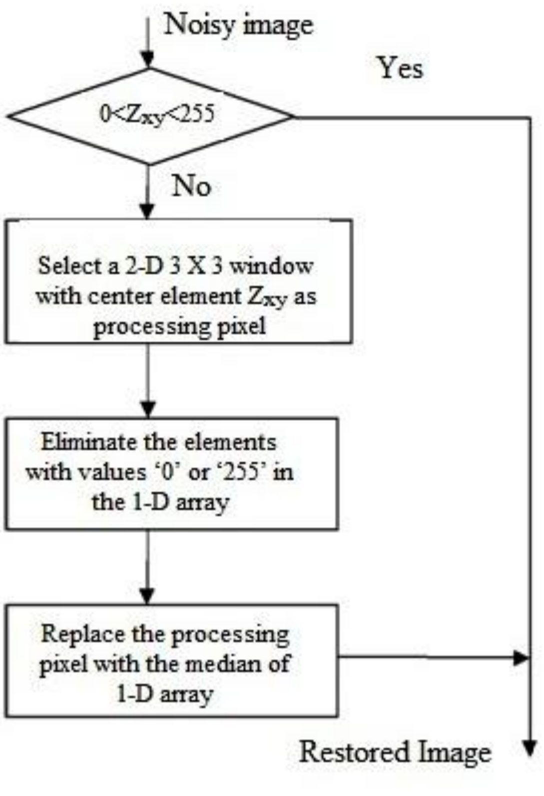


Figure.5. Flow Chart For DBUTM

Illustration:

The figure 6 shows an image matrix. In the first window at the left end, the processing pixel is '57' which lies between '0' and '255'. Hence the processing pixel is uncorrupted andleft unchanged. However, in the second window, the center processing pixel '255' which is noisy is replaced by the median of the neighborhood pixels which is found by eliminating '0' and '255' among the neighborhood pixels (here median=63).

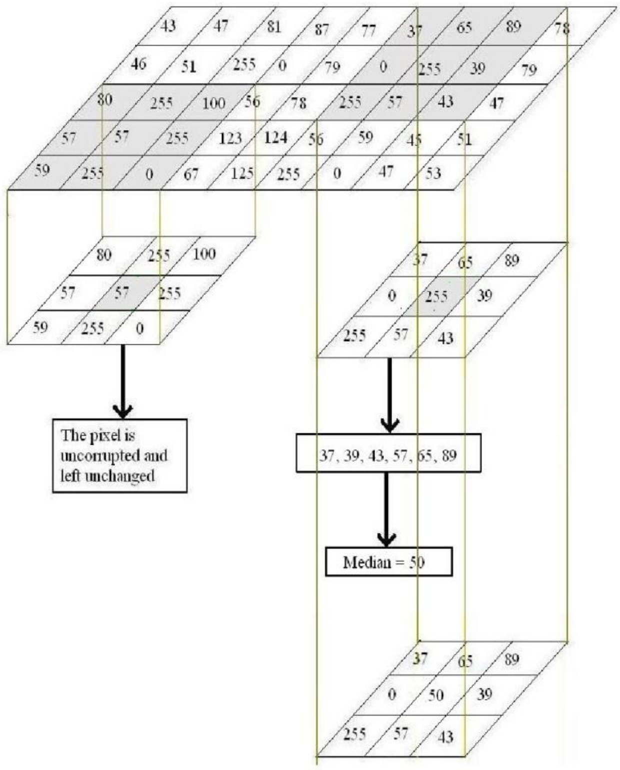


Figure.6. Illustration for DBUTM

B. IMPLEMENTATION FOR VIDEO SEQUENCE

The video sequence is first converted into frames and frames into images. Then DBUTM algorithm is applied to the images which are separated from frames. After the filtering process, the frames are converted back to the original movie.

Algorithm:

Video to frames: The noisy video sequence containing impulse noise is converted into avi format, which is an uncompressed format and frames are extracted from the video.

Frames to images: Frames are then converted to images for further processing.

Filtering method: The noisy images are de noised using DBUTM algorithm.

Frames to movie: After completing the entire process, the processed frames are finally converted back into original movie.

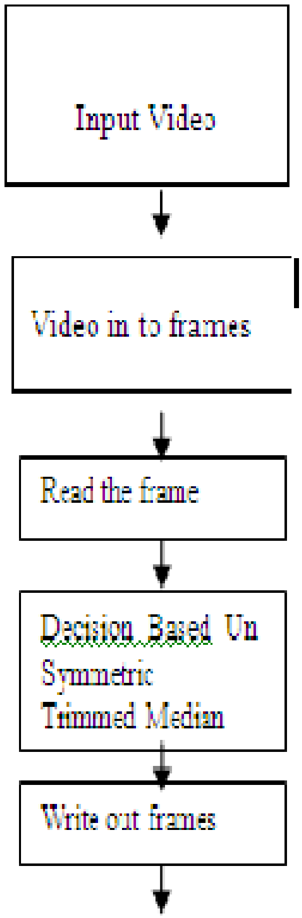


Figure 7. Flowchart for processing a Video Sequence by DBUTM algorithm

IV. RESULTS AND DISCUSSION

The developed algorithms are tested using 512X512, 8-bits/pixel image Lena (Gray), Parrot (color), Barbara (color). The performance of the proposed algorithm is tested for various levels of noise corruption and compared with standard filters namely standard median filter (SMF), adaptive median filter (AMF) and decision based algorithm (DBA) . Each time the test image is corrupted by salt and pepper noise of different density ranging from 10 to 90 with an increment of 10 and it will be applied to various filters. In addition to the visual quality, the performance of the developed algorithm and other standard algorithms are quantitatively measured by the following parameters such as peak signal-to-noise ratio (PSNR), Mean square error (MSE) and Image Enhancement Factor (IEF) . All the filters are implemented in MATLAB 7.1 on a PC equipped with 2.4 GHz CPU and 1 GB RAM memory for the evaluation of computation time of all algorithms. The quantitative performances in terms of PSNR, MSE and IEF for all the algorithms are given in Table II and Table III.

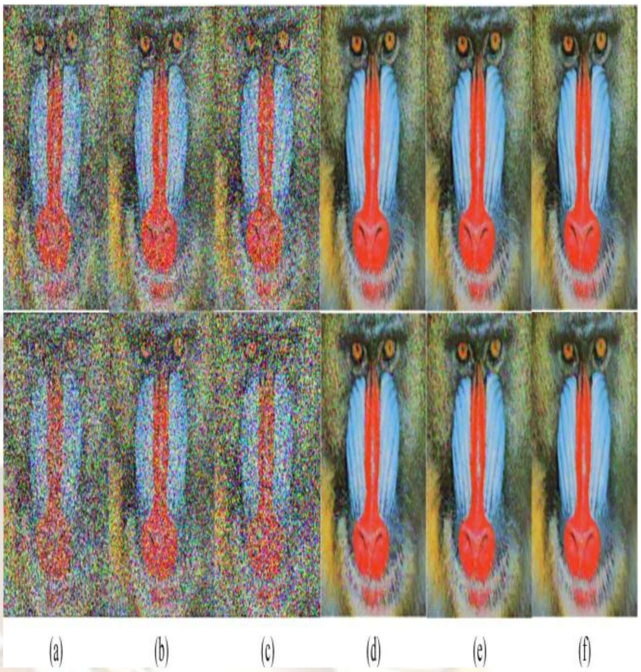


Fig. 2. Results of different algorithms for color Baboon image. (a) Output of SMF. (b) Output of AMF. (c) Output of PSMF. (d) Output of DBA. (e) Output of MDBA. (f) Output of MDBUTMF. Rows 1 and 2 show processed results of various algorithms for color image corrupted by 70% and 80% noise densities, respectively.

Table IIQuantitative results of various filters for 30% corrupted Baboon image

METRICS	SMF	AMF	DBA	DBUTM
PSNR	32.84	32.99	29.09	44.37
MSE	32.74	32.64	66.98	2.13
IEF	22.01	62.4	58.6	78.82

Table III

Quantitative results of various filters for 90% corrupted Baboon image

METRICS	SMF	AMF	DBA	DBUTM
PSNR	32.2786	32.11	27.6836	39.68
MSE	40.2356	37.3265	110.77	7.1282
IEF	1.9	14.59	22.71	66.45

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

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

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

V. CONCLUSION:

An efficient non-linear algorithm to remove high-density salt and pepper noise is proposed. The modified sheer sorting architecture reduces the computational time required for finding the median. This increases the efficiency of the system. The algorithm removes noise even at higher noise densities and preserves the edges and fine details. The performance of the algorithm is better when compared to the other architecture of this type. 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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