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RESEARCH ARTICLE

REMOVAL OF HIGH DENSITY SALT AND PEPPER NOISE IN IMAGES AND VIDEOS USING DENOISING METHODS

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Abstract: ***Now a days visual information transmitted in the form of digital images is becoming a major method of communication, but the image obtained after transmission is often corrupted with noise. Noise hides the important details of images. To enhance the image qualities, we have to remove noises from the images without loss of any image information. Image denoising is one such powerful methodology which is deployed to remove the noise through the manipulation of the image data to produce very high quality images. There are different types of noises which corrupt the images. These noises are appeared on images in different ways: at the time of acquisition due to noisy sensors, due to faulty scanner or due to faulty digital camera, due to transmission channel errors, due to corrupted storage media. Impulse noise in image is present due to bit errors in transmission or induced during the signal acquisition stage. There are two types of impulse noise, like 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 non-linear filters have been established as reliable method to remove the salt and pepper noise without damaging the edge details, each having their own merits and demerits. This paper presents a review on the existing non-linear Median Filters for the removal of high density salt and pepper noise. The basic nonlinear filter i.e. standard median filter (MF) and different variants such as adaptive median filters (AMF), and decision based median filters (DBMF) are shows better results at low and medium noise densities. At high noise densities, their performance is poor. In this paper, Modified Shear Sorting Method and Decision Based UnSymmetric Trimmed Median Filter (DBUTM) are used for removal of high density salt and pepper noise in images and videos, because it has lower computation time when compared to other standard algorithms. Results of the algorithm are compared with various existing algorithms and this method has better visual appearance and quantitative measures at higher noise densities as high as 90%.***

Key words: ***Noise; Denoising; Salt and pepper noise; Median filters***

I. INTRODUCTION

The image processing is an important process in every life application. Image processing is an electronic domain where in image is divided into small unit called pixel and then various operation is carried out. When an image is formed, factors such as lighting (spectra, source and intensity) and camera characteristics

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(sensor response, lenses) effect the appearance of the image. So, the prime factor that reduces the quality of the image is Noise. Noise hides the important details of images. There are different types of noises which corrupt the images. These noises are appeared on images in different ways: at the time of acquisition, due to noisy sensors, due to faulty scanner or due to faulty digital camera, due to transmission channel errors, due to corrupted storage media.

In image processing, the impulse noise reduction from images plays a very vital role. Impulse noise in images is present due to bit errors in transmission or induced during the signal acquisition stage. There are two types of impulse noise, like 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. The removal of noise from the image is known as Denoising.

Image denoising is one of the most common and important image processing operations in image and video processing applications. The important property of a good image denoising model is that, it should completely remove noise as far as possible as well as preserve edges. Traditionally there are two types of denoising models, i.e. linear filtering and non linear filtering. The main aim of the filtering is to eliminate outliers with maximum signal distortion to the recovered noise free image.

Many types of linear filters removes salt and pepper noise but blur the image, the linear approaches were very popular because of its mathematical simplicity. In linear filtering denoising techniques is directly applied to the image pixel without checking the availability of noisy and non noisy pixels. The examples of linear filtering are Mean filter. The disadvantage of this filter is it will affect the quality of non noisy pixel. In the case of non linear filter, this is done by two steps first detection then filtering. First step the position of the noise is detected and in the second step replace the noisy pixel with calculated value.

Non linear filtering techniques are implemented widely because of their superior performance in removing salt and pepper noise and also preserving fine details of image. There are many works on the restoration of images corrupted by salt and pepper noise. The median filter was once the most popular non linear filter for removing impulse noise, because of its good denoising power and computational efficiency. Median filters are known for their capability to remove impulse noise as well as preserve the edges.

II. SOME EXISTING NOISE REMOVAL TECHNIQUES

Standard Median Filter

Standard Median Filter was once the most popular non linear digital filter for removing impulse noise because of its good denoising power and computational efficiency. Standard Median Filtering is the simplest non linear filtering technique where the value of each pixel is replaced by the median of the gray levels in the neighbourhood of the corresponding pixel regardless of whether it is corrupted or not. The Standard Median Filter is a reliable method to remove salt and pepper noise without damaging the edge details. This filtering requires arranging the pixel values either in increasing or decreasing order and replaces the noisy pixel by the median of its neighbourhood values. The main drawback of Standard Median Filter is that, it is effective only for low noise densities. The filter is not effective for high noise densities, i.e. when the noise level is too high the edge details of the original image will get lost and also the standard median introduced too much distortion in the processed image. So Adaptive Median Filter is introduced.

Adaptive Median Filter

The adaptive median filter is non linear filter. 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 another pixels unchanged. The basic difference between the Adaptive Median Filter and the Standard Median Filter is that, the Adaptive Median Filter changes the window size during the filtering operation, depending on the noise density of the image. To reduce the noise by using varying the window size, to increases the size of the window until correct value of median is calculated and noise pixel is replaced with its calculated median value. Here two conditions are used, one condition is used to detect the corrupted pixels and

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second one is used to check the correctness of median value. Check that the pixel is less than minimum value available in window and also the pixel is greater than maximum value present in window then centre pixel is considered as corrupted pixel. Then check that the median value less than minimum pixel value available in window and median is greater than maximum pixel value available in window, then median value is judge as noisy pixel. If calculated median is corrupted then increase the window size and recalculate the median value until we get correct median value or else window size reach maximum limit.

The performance of Adaptive Median Filter is good at lower noise density levels, due to the fact that there are only fewer corrupted pixels that are replaced by the median values. But at higher noise densities, both the corrupted and uncorrupted pixels in the neighbourhood of an impulse corrupted pixel are considered to determine the noise replacing value. So the window size has to be increased which may lead to blur the image. The main drawback of the Adaptive Median Filter is that at high noise density the adaptive nature increases the window larger and larger to obtain a valid median value. Also, there is a possible that the median value obtained from larger window will not be accurate one.

Progressive Switching Median Filter

It is a median-based filter, which works in two stages. In the first stage an impulse detection algorithm is used to generate a sequence of binary flag images. This binary flag image predicts the location of noise in the observed image. In the second stage noise filtering is applied progressively through several iterations. This filter is a very good filter for fixed valued impulse noise but for random values the performance is abysmal.

The advantage of using Progressive Switching Median Filter preserves the positions of boundaries in an image, making this method useful for visual examination and measurement. But the disadvantage is to removes both the noise and the fine detail since it cannot tell the difference between the two. To overcome the above drawback Decision Based Algorithm is proposed.

Decision Based Algorithm

In decision based algorithm, the pixel value inside the window are sorted in ascending order and the middle element of the window is consider as median value of that window. If the processing pixel takes the value of minimum and maximum gray levels, then it is consider as corrupted pixel and it is replaced by median of its neighbourhood pixels. If the median of the neighbourhood pixels also takes the value of 0 or 255, then the processing pixel is replaced by the value of its neighbourhood pixel value.

The drawback of this algorithm is at high noise density the neighbouring pixel is used repeatedly for replacing the noisy pixel which degrades the quality of restored images, called streaking effect. In order to avoid this drawback Decision Based Unsymmetric Trimmed Median Filter is proposed.

III. BRIEF REVIEW ON SORTING ALGORITHMS

Shear Sorting Algorithm

Sorting is the most important operation used to find the median of a window. There are different 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 general the parallel architectures help to reduce the number of logic cells required for its implementation. The basic idea of shear sort is to arrange the data into rows and columns in a grid allowing us to sort those rows and columns concurrently.

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Fig. 1 Numbers that are to be sorted arranged in group of five

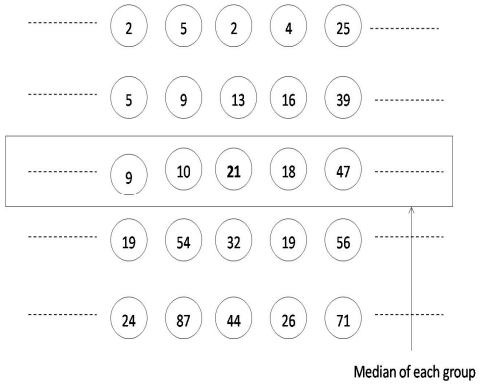

Fig. 2 Median of each group shown in the middle

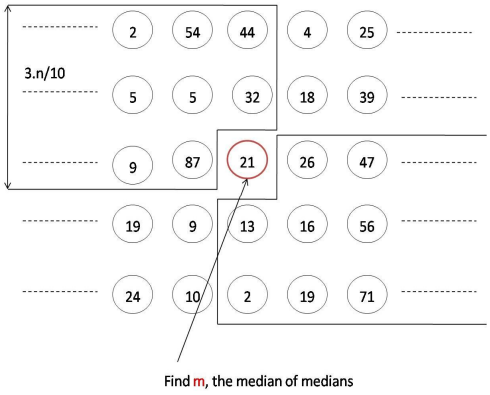

Fig. 3 Median of Medians of all groups shown in the middle

The general procedure of sort can be understood from the fig1-3. Sort each of the group in O (n) time. Finding the median of each group for a given set (……..2, 5, 9, 19, 24, 54, 5, 87, 9, 10, 44, 32, 21, 13, 24, 18, 26, 16, 19, 25, 39, 47, 56, 71, 91, 61, 44, 28……) having **n** elements.

The above figures show the general procedure of median calculation using sorting technique. The illustration of shear sorting is shown in figure. 4-7. in the odd phases (1, 3, and 5) even rows is sorted in descending order and rows are sorted out in ascending order. In the even phases columns are sorted out independently in ascending order.

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13	17	12
18	11	19
15	14	16

Fig. 4 Matrix before Sorting (Original)

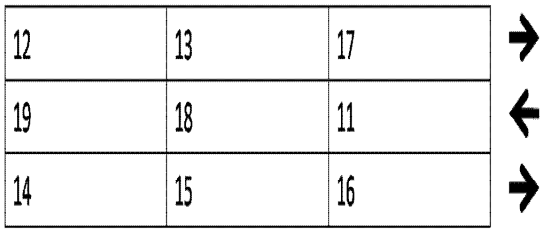

Fig. 5 Row Sorting (Step-1)

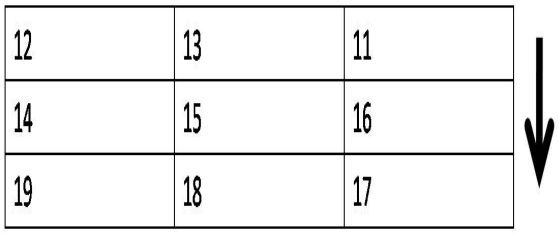

Fig. 6 Column Sorting (Step – 2)

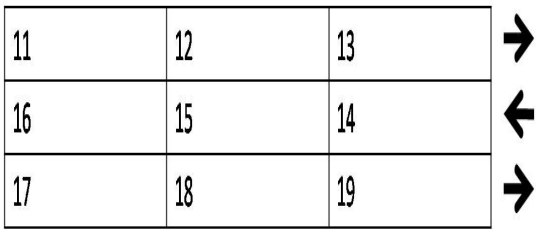

Fig. 7 Row Sorting (Step-3)

Modified Shear Sorting Algorithm

In order to improve the computational efficiency Shear Sorting algorithm is modified as follows:

1. All the three rows of the window are arranged in ascending order.
2. Then all the columns are arranged in ascending order.
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.

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The illustration of sorting algorithm is shown in the table containing the comparison of the various sorting techniques.

Table 1
Comparison of the various sorting techniques

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

IV. UNSYMMETRIC TRIMMED MEDIAN FILTER

The idea behind a trimmed filter is to reject the noisy pixel from the selected 3**X** 3window. Alpha Trimmed Mean Filtering (ATMF) is a symmetrical filter where uncorrupted pixels are also trimmed. This leads to loss of image details and blurring of the image. In order to overcome this drawback, an Unsymmetric Trimmed Median Filter (UTMF) is proposed. In this UTMF, the selected 3**X**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.

V. DECISION BASED UNSYMMETRIC TRIMMED MEDIAN FILTER

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.

Algorithm (For Image)

The Actual Block Diagram for removing the noise from noisy image.

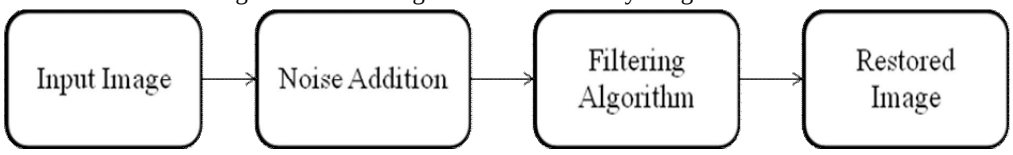

Fig 8. Flowchart for processing an image Sequence by DBUTM

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The algorithm for DBUTM is as follows:
Step 1) A 2-D window **"S_{xy}"** of size 3 X 3 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.

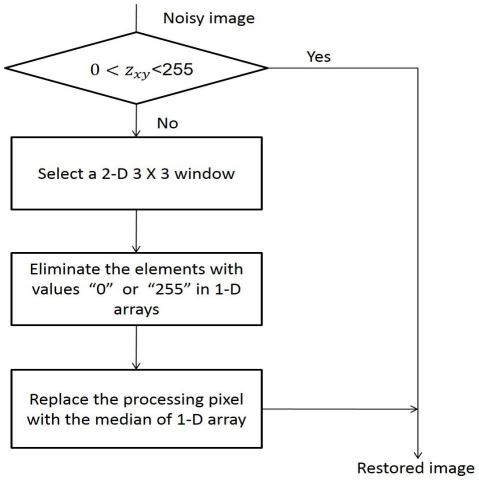

Fig 9. Flow Chart for DBUTM

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 video. The below figure 10 shows the process flow.

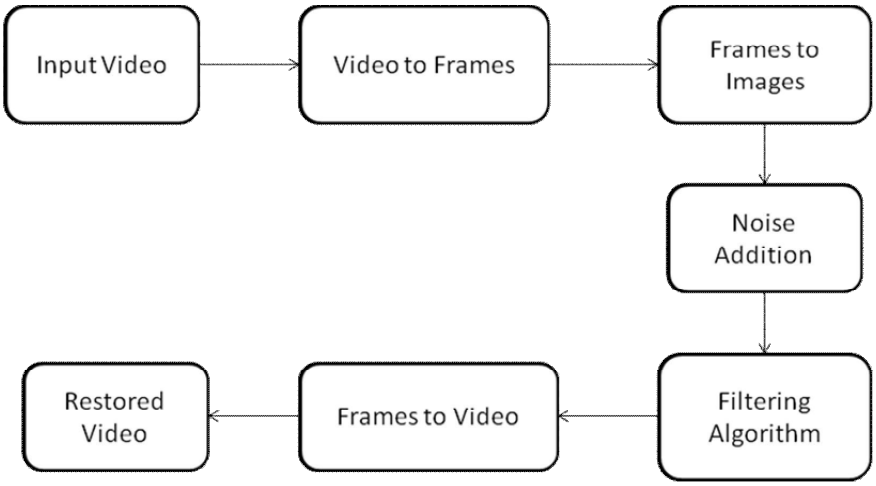

Fig 10. Flowchart for processing a Video Sequence by DBUTM

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Algorithm (For Video)

1. Video to Frames: The noisy video sequence containing Impulse noise (Salt and Pepper noise) is converted into frames at 24 f/s rate.
2. Frames to Images: Frames are then converted in to images to pass through the Filtering process to remove the Impulse noise presented.
3. Filtering: The impulse noise from the noisy images is removed using DBUTM algorithm.
4. Frames to Movie: After removal of impulse noise from all noisy images, the frames are converted back in to original video.

VI. EXPERIMENTAL RESULTS

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 on a PC equipped with 2.4 GHz CPU and 1 GB RAM memory for the evaluation of computation time of all algorithms.

CALCULATIONS

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

$$MSE = \frac{\sum_y \left(r_{ij} - x_{ij}\right)^2}{MN}$$

$$IEF = \frac{\left(\sum_y n_{ij} - r_{ij}\right)^2}{\left(\sum_y x_{ij} - r_{ij}\right)^2}$$

a b c d e f

Fig 11. Results for 90% noise corrupted Lena image (a) original Lena image (b) 90% noise corrupted image. Restoration results of (c) SMF (d) AMF (e) DBA (f) DBUTM.

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Table 2
Quantitative results of various filters for 90% corrupted Lena image

METRICS	SMF	AMF	DBA	DBUTM
PSNR	12.0	15.2	19.4	22.5
MSE	8024.4	1045.2	894.24	134
IEF	2.4	15.68	31.21	67.54
C time	2.98	69.43	9.12	6.78

VII. 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.

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