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A NEW TRISTATE SWITCHING MEDIAN FILTERING TECHNIQUE FOR IMAGE ENHANCEMENT

Stephane Alda, Adawiah
Faculty of Engineering, Islamic University of Kalimantan Muhammad Arsyad Al Banjari Banjarmasin

Research Article

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ABSTRACT

When salt and pepper noise deteriorates digital photos, a novel Tristate Switching Median Filtering Technique is suggested for their improvement. Two decision-based filters are integrated with a switching method to create the suggested filter. This method is used to identify and minimize impulsive noise in digital photos. The suggested filter performs better in terms of eliminating impulsive noise while maintaining picture features, according to extensive simulation findings.

Index Terms — Decision based median filter, Impulse noise detection, Salt and Pepper noise and switching logic.

INTRODUCTION

Impulse noise often taints digital photographs during image capture or transmission via a communication channel. Linear filters were the main instruments used in the early development of signal and picture processing. They were simple to create and execute due to their mathematical simplicity and the presence of several desired features. Nonetheless, linear filters perform poorly when non-additive noise is present and when non-Gaussian statistics or system nonlinearities exist
came across. Additionally, since they blur the picture borders, linear filters are not shown to be more effective for processing the images [1–3].

Over the years, a number of filtering methods that are appropriate for different applications have been documented in the literature. Without taking into account whether a pixel is damaged or not, a conventional median filter applies the median operation to every pixel. Consequently, the uncorrupted pixels' contribution to the picture details is still filtered, which degrades the image quality. Using an impulse-noise detection system before filtering is a logical way to solve this issue. As a result, only the pixels that were determined to be tainted would be filtered; the other pixels would not be affected. Another name for this impulse detection method is the Detail Preserving Scheme or Switching Scheme.

The whole filtering process is divided into two successive parts by Switching Median Filtering (SMF): filtering and noise detection. The contaminated pixel is located using the decision method, and median-based filtering is applied. The pixels that are categorized as uncorrupted are not affected by the median-based switching approaches. The precision of the noise identification is obviously crucial for removing impulsive noise and maintaining edges and fine details in all switching median filtering algorithms [4]–[14].

Numerous decision-based algorithms for impulse noise reduction have been studied in order to address these issues [15–25]. While digital pictures are tainted by increasing levels of impulse noise, these filters are found to perform poorly in terms of maintaining edges and fine details, despite their satisfactory suppression of impulse noise. Decision-based switching filtering approaches are presently being studied and documented in the literature to enhance the performance of current filters in terms of noise reduction and feature preservation qualities.

Two requirements must be met by a decent noise filter: (1) the noise must be suppressed, and (2) the signal's relevant information must be preserved. However, when the pictures are distorted by greater levels of impulsive noise, the vast majority of noise filters that are now on the market do not simultaneously meet both of these requirements.

A New Tristate Switching Median Filter (NTSMF) is suggested to improve the pictures corrupted at greater levels of salt and pepper noise by appropriately combining switching filters with decision-based

median filters. Two decision-based filters [23 and 24] are integrated with a switching method to create this filter. This suggested filter is a compromise between decision-based and thresholding filters. The results of in-depth simulation experiments will be used to demonstrate the filtering properties of the suggested filter. The quality of photographs is improved for human visual perception via image augmentation.
There are four parts in this study. Section 2 describes the impulse detecting technique. In section 3, the filtering algorithm is explained. The findings of comprehensive simulation simulations conducted to assess the filter's effectiveness are presented in Section 4. The conclusion has been reached in Section 5.

IMPULSE DETECTION

Impulse Detection

An impulse detector can realize detection of noise. In this work the absolute difference between the central pixel value for the given input image and the central pixel value from decision based filter provides a good measurement. Based on this absolute difference only, the impulse can be detected.

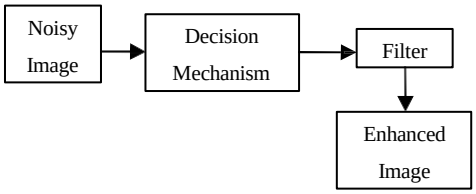


Fig.1 Block diagram of impulse detection techniques

Fig.1 illustrates the overall impulse detection techniques. The impulse detector is used to detect the impulse noise from sources, which is based on the thresholding (switching logic). Then the detected impulse noise can be eliminated using nonlinear filter. A threshold T controls switching logic. For the grayscale image, the threshold value should be from 0 to 255. Existing tristate filter depends only on thresholding logic and weight changing properties of median based filters. Always median based filters alter both noisy as well as noise free pixels of digital images. In order to overcome this drawback; instead of median based filters, decision based median filters are selected in this paper.

FILTERING ALGORITHM

Thresholding is the term for switching, when a single fixed threshold is chosen for each pixel in a picture. The digital pictures are adequately restored by the thresholding performance, even at lower noise levels. It is discovered to function poorly when pictures with medium and greater levels of impulse noise are distorted. The primary benefit of current tri-state median filters [4 and 25] is that they combine the two filters into a new one and use their benefits to more effectively minimize the degrading qualities of impulsive noise. This idea is supported by the proposal of a novel tristate filter for heavily polluted photos.

proposed Tristate filtering algorithm

The Tristate filter is obtained by suitably combining the output images from decision based median filter-1 and decision based median filter-2. Consider an image of size M×N having 8-bit gray scale pixel resolution is selected for these two filters. These decision based median filters are described in the following section 3.1.1 and 3.1.2 and then section 3.1.3 explains the proposed tristate filtering.

Decision based Median Filter-1

This filter has been illustrated in [24]. In this filter, edges on the noisy image are identified using one of the properties of edge detection. The central pixel is identified as corrupted one; it is replaced by the proposed edge preserving method. Therefore, edges on the image is detected by computing gradient value in the direction of horizontal, vertical, left diagonal and right diagonal within the filtering window respectively. Based on neighborhoods within the filtering window, the gradient value is obtained by

determining the difference of two pixel intensities in direction of vertical (N and S), horizontal (W and E), left diagonal (SW and NE) and right diagonal (NW and SE) respectively. {NW = North West, N = north, NE = North East, W = west, E = east, SW = South West, S = south, SE = South East}. These four gradients of vertical, horizontal, left diagonal and right diagonal values respectively. These four gradient values (according to the four different directions or neighbors) are considered for the decision to eliminate impulse noise as well as preserve the edges of the image. If the gradient value is quite large, any one of the pixel is affected in the corresponding direction with minimum/maximum value of impulse noise.

The minimum gradient value is a good indication that those pixels are noise free edge pixels in the direction of orientation. The minimum gradient value with respect to (i,j) can be used to determine the direction of orientation of edge pixel. In order to preserve the edges, the corrupted central pixel is replaced by the average of two intensities which are obtained with respect to the direction of minimum gradient value. Then the window is moved to form a new set of values, with the next pixel to be processed at the centre of the window. This process is repeated until the last image pixel is processed.

Decision based Median Filter-2

In this section, homogeneous region of image is preserved by applying decision based switching median filtering technique and it has been illustrated in [23]. The pixels inside the sliding window are classified as corrupted and uncorrupted pixels by comparing their values with the maximum (255) and minimum (0) values. A two-dimensional square filtering window of size 3 x 3 is slid over the noisy image. As the window move over the noisy image, at each point the central pixel inside the window is checked whether it is a corrupted pixel or not. If the pixel is an uncorrupted one, it is left undisturbed and the window is moved to the next position. Separate the corrupted and uncorrupted pixels inside the filtering window at its current position. Check if the uncorrupted pixels inside the window add up to an odd number. If so, the median of the uncorrupted samples is set out as the filter output. If the uncorrupted samples sum up to an even number, then the Range Estimator (RE) is determined for the uncorrupted samples.

A suitable threshold value T is chosen for determining the presence of an edge at the central pixel. If RE is greater than the threshold value T, the central pixel is declared an edge and therefore, it left unaltered; otherwise, the central pixel is replaced by the arithmetic average of the uncorrupted pixels inside the filtering window. Then the window is moved to form a new set of values, with the next pixel to be processed at the centre of the window. This process is repeated until the last image pixel is processed.

Proposed new Tristate filtering algorithm

A new switching scheme, called *tri-state median* (TSM) filter, is proposed and discussed in this section. Impulse noise detection is realized by an impulse detector, which takes the outputs from the *Decision based Median Filter -1* and *Decision based Median Filter -2* filters and compares them with the origin or center pixel value within the filtering window on given contaminated digital image in order to make a tri-state decision. The switching logic as shown in Fig. 2 is controlled by a threshold T (T = 24; [0 - 255] for gray-scale images).

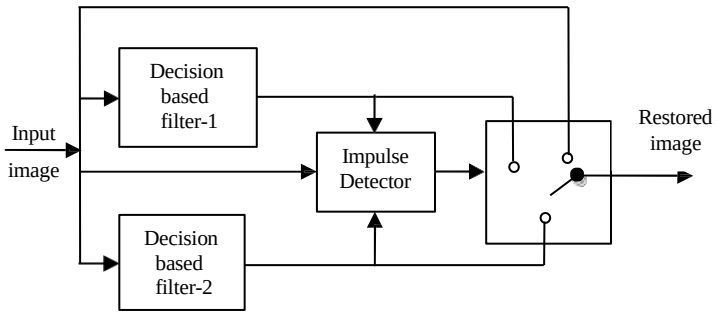


Fig. 2 Tri state based median impulse detector

Fig.2 Illustrate the switching logic for newly proposed Tristate decision based median filter. Here, there are two types of comparison can be carry out to improve the noise reduction. First one is based on

decision based median filter1 and second one is based on decision based median filter2. The absolute difference between original pixel value from noisy image and center pixel value from filtered image is compared with threshold value. This comparison is based on the following condition:

$d1 = |A(i,j) - Y_{DBF1}(i,j)|$ (1)

$d2 = |A(i,j) - Y_{DBF2}(i,j)|$ (2)

where, *d1* is an Absolute difference between original pixel value and decision based median filter1 (DBF1), *d2* is an Absolute difference between input pixel value and decision based median filter2 (DBF2)output, *A(i,j)* is the Noisy image, $Y_{DBF1}(i,j)$ is the decision based median filtered (DBF1) output, $Y_{DBF2}(i,j)$ is the decision based median filtered (DBF2) output. This impulse noise detection and filtering is based on the following condition:

if T > d1(i,j)
{Z(i,j) = Noisy free image} end
if T < d2(i,j)
{$Y_{DBF2}(i,j)$ = DBF1 *output} end*
if d2(i,j) ≤ T < d1(i,j)
{$Y_{DBF2}(i,j)$ = DBF2 *output} end*

where, T is the threshold value and the tristate decision depends on fixing the threshold value. Various threshold values are applied one by one. Among these T=24 gave optimum value for quantitative and qualitative measures. Therefore this value is chosen for the proposed filtering technique.

The existing tristate median filters had been investigated by utilizing median based filters. (i.e. standard median and centre weighted median filter). These median based filters are used to identify the nearest neighborhood pixels in local statistics and also filtering operation is controlled by fixed threshold value. Therefore it explores the advantages of integrated filters. Even though the proposed filter utilizes median based filters as base filter for tristate switching logic so it exhibit insufficient recital in terms of noise elimination and edge preservation when digital images are corrupted by higher level of impulse noise. Constantly the performance of median based filters like weighted median filter and center weighted median filter alter noisy and noise-free pixels on digital images. Therefore decision based median filters are considered as base filters and are suitably combined, referred as ***Tristate Switching Median Filter for Image Enhancement***. Because decision based median filters are used to minimize the misclassification of pixels on digital images and also it show improved performance in terms of impulse noise elimination and edge preservation of images.

IV. SIMULATION RESULTS

The filtering technique is tested using 3 x 3 windows with Lena image of size 256 x 256. In this paper, Lena image is used as a test images. In order to analyze the performance of the proposed filter approach, the performance evaluation factors like Peak Signal to Noise Ratio (PSNR) is used. This performance evaluation is based on threshold values and noise levels. Filter has higher PSNR values are considered to be superior filter in terms of noise elimination and restoration of image features. A New Tristate Switching Median Filtering Scheme (NTSMF) is quantitatively evaluated using objective measures are defined as:

$$PSNR = 10\log_{10}\left[\frac{255*255}{MSE}\right] \quad (3)$$

where,

$$MSE = \frac{\sum_{row,col}|X(i,j) - F(i,j)|^2}{row*col} \quad (4)$$

(i,j) denotes the number of rows and columns in the image data, *X(i,j)* represents the pixel intensities of the original image at the position of *X(i,j)*, *F(i,j)* represents the output intensities in the filtered image at the position of (i,j). The proposed filter has very good subjective improvements for lower level of mixed impulse noise (i.e. fine details preservation of the image). The enhancement result for the corrupted 'Lena' image by different level of impulse at suitable threshold has been estimated. The estimated values are tabulated and are given in the Table1.

TABLE.1

PSNR VALUES OBTAINED USING PROPOSED FILTER AND COMPARED WITH DIFFERENT FILTERING TECHNIQUES ON LENA IMAGE CORRUPTED WITH VARIOUS DENSITIES OF IMPULSE NOISE

Filtering Techniques	Noise Level in %								
	10	20	30	40	50	60	70	80	90
MF	31.74	28.23	23.20	18.80	15.28	12.41	9.98	8.24	6.58
WMF	23.97	23.06	22.58	21.65	20.11	18.55	15.73	12.65	8.83
CWMF	28.72	23.80	20.28	17.28	14.45	11.96	10.04	8.24	6.75
TSMF	32.89	28.35	24.96	20.06	16.82	13.93	11.33	9.11	7.58
MDBSMFS	34.83	30.03	24.79	20.59	16.99	13.92	11.28	8.89	6.97
NID	37.90	31.85	28.75	26.52	23.42	18.89	14.65	10.83	7.77
IDBA	36.5	33.39	29.72	28.64	26	24.40	23.5	22.64	19.3
DBF1	40.8	35.8	31.0	27.3	22.6	17.6	13.42	9.63	7.06
DBF2	38.42	34.28	30.47	27.38	24.92	22.05	18.84	14.12	10.03
Proposed Filter	42.57	38.87	35.38	33.17	29.34	25.75	19.52	13.47	10.13

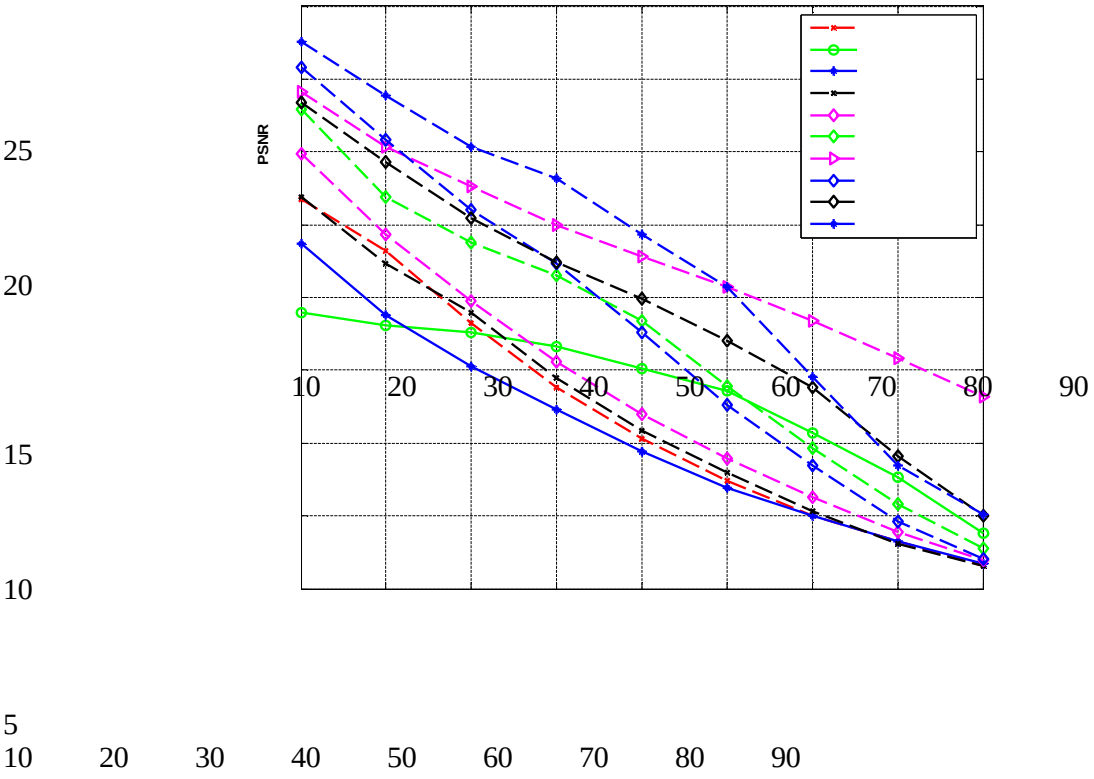
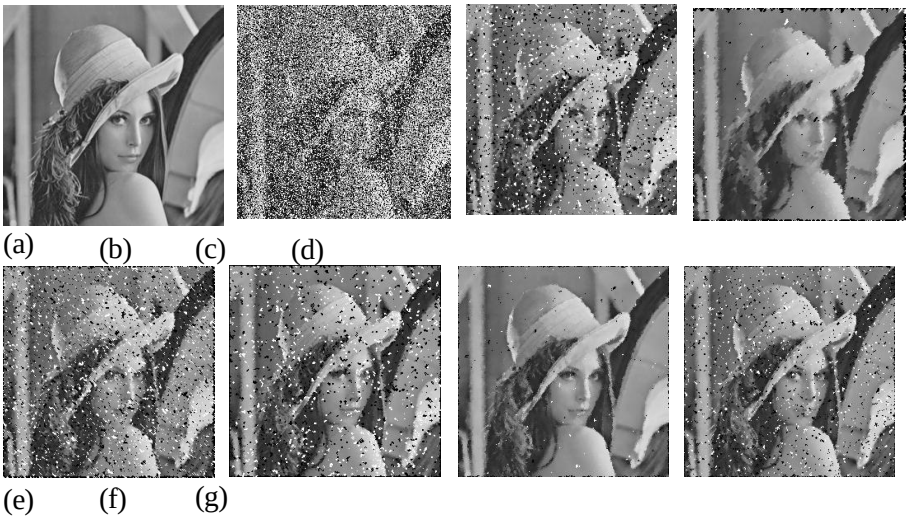


Fig.3 PSNR obtained using proposed filter on Lena image corrupted with different densities of impulse

noise and compared with other existing filtering techniques

Figure 3 illustrates the objective performance for human visual perception and Figure 4 graphically illustrates the objective improvement of the proposed filter with respect to other switching schemes. The performance of this filter is evaluated using various impulse corruption ratios from 10% to 90% with suitable threshold. This filter has better performance than the other filtering schemes for the noise densities up to 50%. It shows that the better performance in removing impulse noise from digital images without distorting the useful information in the image.



(a) (b) (c) (d)

(e) (f) (g) (h)



(i) (j) (k) (l)

Fig.4 Subjective Performance comparison of proposed filter with other existing filters on test image Lena (a) Noise free images, (b) image corrupted by 50% impulse noise, (c) images restored by MF, (d) images restored by WMF, (e) images restored by CWMF, (f) images restored by TSMF, (g) images restored by MDBSMF, (h) images restored by NID, (i) images restored by IDBA, (j) images restored by DBF 1, (k) image restored by DBF 2 and (l) image restored by the proposed filter

CONCLUSION

The effectiveness of the suggested filtering method is examined in this research, and it works effectively for digital photos that have up to 50% impulsive noise contamination. Since the digital image's damaged pixels can be precisely identified by the new impulse detection technology, the estimated center noise-free ordered median value is used in their stead. The filtering approach performs better in terms of both quantitative and qualitative assessments, according to extensive simulation data.

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