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A NEW TRISTATE SWITCHING MEDIAN FILTERING METHOD FOR IMAGE IMPROVEMENT

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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 — switching logic, impulse noise detection, salt and pepper noise, and decision-based median filtering.

1. 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. Nevertheless, linear filters perform poorly when non-additive noise is present, as well as when system nonlinearities or non-Gaussian statistics are present. 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 quality 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.

2. IMPULSE DETECTION

2.1 Impulse Detection

Noise detection is possible using an impulse detector. A suitable measurement in this study is the absolute difference between the center pixel value from the decision-based filter and the central pixel value for the input picture. The impulse may be identified based only on this absolute difference.

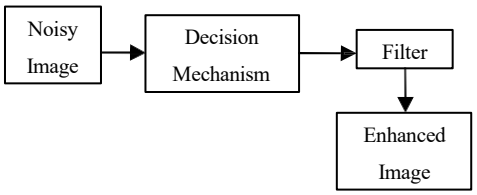


Fig.1 Block diagram of impulse detection techniques

The general impulse detection methods are shown in Fig. 1. The impulse detector, which is based on thresholding (switching logic), is used to identify impulse noise from sources. After that, a nonlinear filter may be used to remove the identified impulse noise. Switching logic is controlled by a threshold T. The threshold value for the grayscale picture should be between 0 and 255. The current tristate filter only relies on the weight-changing characteristics of median-based filters and thresholding logic. Digital pictures' noisy and noise-free pixels are always altered by median-based filters. In this research, decision-based median filters are used in place of median-based filters to address this shortcoming.

3. 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.

3.1 proposed Tristate filtering algorithm

The output pictures from decision-based median filter-1 and decision-based median filter-2 are appropriately combined to create the tristate filter. For these two filters, a picture of size M×N with an 8-bit grayscale pixel resolution is used. Sections 3.1.1 and 3.1.2 discuss these decision-based median filters, while section 3.1.3 describes the suggested tristate filtering.

3.1.1 Decision based Median Filter-1

An illustration of this filter may be seen in [24]. One of the edge detection features is used in this filter to identify edges on the noisy picture. The suggested edge preservation technique replaces the middle pixel, which is determined to be contaminated. Consequently, gradient values in the horizontal, vertical, left, and right diagonal directions inside the filtering frame are computed to identify edges on the picture. The gradient value is calculated by subtracting two pixel intensities in the directions of vertical (N and S), horizontal (W and E), left diagonal (SW and NE), and right diagonal (NW and SE), respectively, based on neighborhoods inside the filtering window. {NW = North West, N = North, NE = North East, W = West, E = East, SW = South West, S = South, SE = South East}. These four gradients represent values that are vertical, horizontal, left diagonal, and right diagonal, respectively. When deciding whether to remove impulsive noise and maintain the image's edges, these four gradient values—which correspond to the four distinct directions or neighbors—are taken into account. Any pixel is impacted in the appropriate direction with the minimum or maximum value of impulse noise if the gradient value is quite significant.

In the direction of orientation, the low gradient value is a reliable indicator that such pixels are edge pixels devoid of noise. The direction of orientation of the edge pixel may be found using the minimal gradient value with regard to (i,j). The average of two intensities calculated with regard to the direction of the minimal gradient value replaces the corrupted center pixel in order to

maintain the edges. The next pixel to be processed is then near the center of the window, and the window is shifted to create a new set of data. Until the last picture pixel is processed, this procedure is repeated.

3.1.2 Decision based Median Filter-2

In this part, the decision-based switching median filtering approach is used to retain the homogenous area of the picture, as shown in [23]. By comparing their values with the maximum (255) and minimum (0) values, the pixels inside the sliding window are categorized as corrupted and uncorrupted. The noisy picture is covered by a 3 × 3 two-dimensional square filtering window. Every time the window moves over the noisy picture, its center pixel is examined to see whether it has been corrupted. The window is shifted to the next place and the pixel is left undisturbed if it is uncorrupted. Inside the filtering window, separate the pixels that are tainted and those that are not. Verify if the sum of the window's uncorrupted pixels is odd. In such case, the filter output is set to the median of the uncorrupted data. The Range Estimator (RE) for the uncorrupted samples is calculated if their total equals an even integer.

To identify if an edge is present at the center pixel, an appropriate threshold value T is used. The center pixel is replaced by the arithmetic average of the uncorrupted pixels within the filtering window if RE is bigger than the threshold value T, in which case it is deemed an edge and left unchanged. The next pixel to be processed is then near the center of the window, and the window is shifted to create a new set of data. Until the last picture pixel is processed, this procedure is repeated.

3.1.3 Proposed new Tristate filtering algorithm

This section proposes and discusses a novel switching technique known as the tri-state median (TSM) filter. An impulse detector is used to detect impulse noise. It does this by comparing the outputs of the Decision based Median Filter -1 and Decision based Median Filter -2 filters with the origin or center pixel value within the filtering window on a 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).

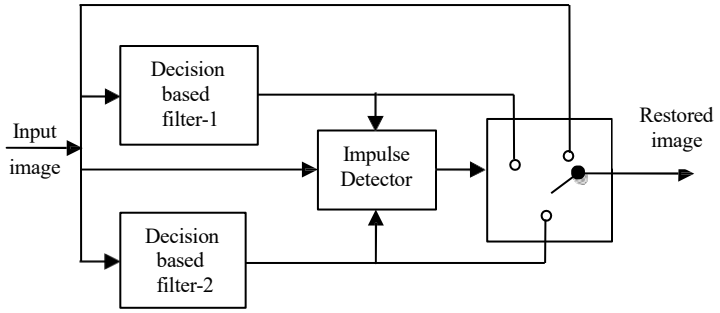


Fig. 2 Tri state based median impulse detector

Fig.2 Give an example of the switching logic for the recently suggested tristate decision-based median filter. To enhance the noise reduction, two kinds of comparisons may be made in this situation. Decision-based median filters 1 and 2 serve as the foundation for the first and second, respectively. The threshold value is compared to the absolute difference between the original pixel value from the noisy picture and the center pixel value from the filtered image. The following condition serves as the foundation for this comparison:

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

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

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:

$$\begin{aligned} &if\ T > d1(i,j) \\ &\{Z(i,j) = Noisy\ free\ image\}\ end \\ &if\ T < d2(i,j) \\ &\{Y_{DBF2}(i,j) = \text{DBF1}\ output\}\ end \\ &if\ d2(i,j) \le T < d1(i,j) \\ &\{Y_{DBF2}(i,j) = \text{DBF2}\ output\}\ end \end{aligned}$$

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.

Using median-based filters, the current tristate median filters were examined. (For example, the center weighted median filter and the ordinary median). The closest neighborhood pixels in local data are found using these median-based filters, and the filtering process is managed by a predetermined threshold value. As a result, it investigates the benefits of integrated filters. The suggested filter exhibits inadequate efficiency in terms of noise reduction and edge retention when digital pictures are contaminated by greater levels of impulsive noise, despite the fact that it uses median-based filters as the basic filter for tristate switching logic. Digital pictures' noisy and noise-free pixels are constantly altered using median-based filters such as the weighted median filter and the center weighted median filter. As a result, decision-based median filters are regarded as basic filters and are appropriately integrated to create the Tristate Switching Median Filter for Image Enhancement. Because decision-based median filters are used to reduce pixel misclassification in digital pictures, they also demonstrate enhanced performance in terms of impulse noise removal and image edge retention.

IV. SIMULATION RESULTS

3 × 3 windows with a 256 by 256 Lena picture are used to evaluate the filtering method. The Lena picture is used as a test image in this article. Peak Signal to Noise Ratio (PSNR) and other performance assessment parameters are utilized to assess the performance of the suggested filter method. Threshold values and noise levels serve as the foundation for this performance assessment. When it comes to removing noise and restoring visual characteristics, filters with higher PSNR values are seen to be better. The following objective metrics are used to quantitatively assess a New Tristate Switching Median Filtering Scheme (NTSMF):

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

where,

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

(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

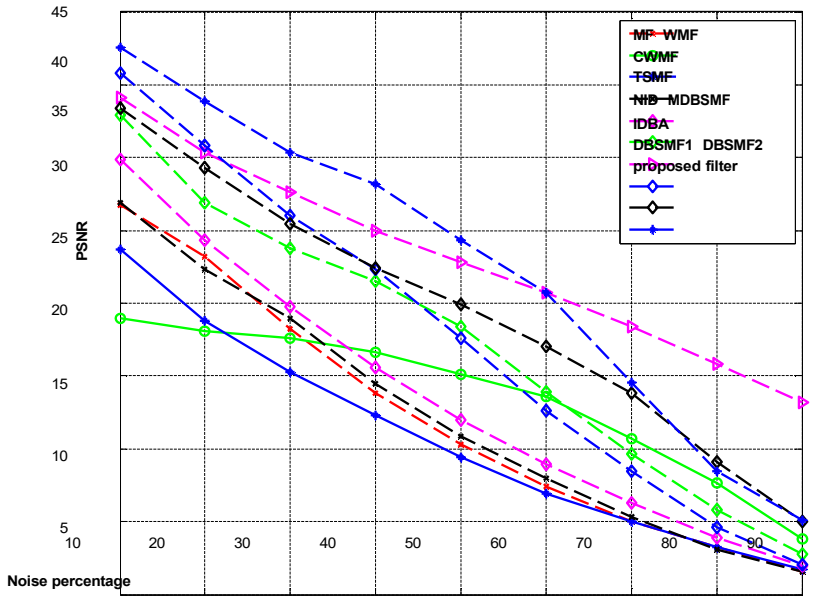


Fig.3 PSNR obtained using proposed filter on Lena image corrupted with different densities of impulse noise and compared with other existing filtering techniques

The objective performance for human visual perception is shown in Figure 3, and the objective

improvement of the suggested filter in comparison to other switching schemes is graphically shown in Figure 4. Using different impulse corruption ratios ranging from 10% to 90% with an appropriate threshold, the filter's performance is assessed. For noise intensities up to 50%, this filter performs better than the other filtering techniques. It demonstrates improved effectiveness in eliminating impulsive noise from digital photos without affecting the image's valuable information.

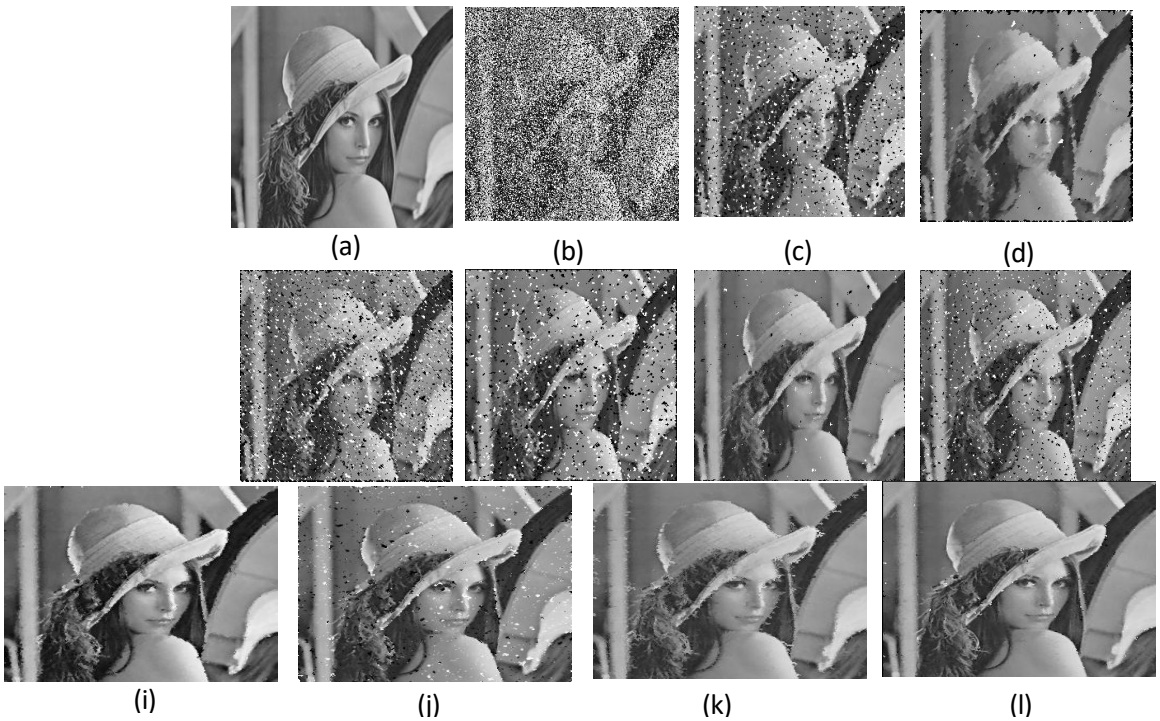


Fig.4 Subjective Performance comparison of proposed filter with other existing filters on test image Lena (a) Noise free images, (b) image corrupted by 50% impulse noise, (c) images restored by MF, (d) images restored by WMF, (e) images restored by CWMF, (f) images restored by TSMF, (g) images restored 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

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

5.
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% impulse 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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