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INTRODUCTION OF A NEW ADAPTIVE TRIMMED MEDIAN FILTER TO REMOVE HIGH DENSITY IMPULSIVE NOISE IN NATURAL IMAGES

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Abstract- Impulse noise is one of the most important factors in degrading of image quality. In this paper, a novel technique is presented for detecting and removing of impulse noise, while the significant information of image, such as edges and texture, are remind untouched. The proposed algorithm use the weighted window with variable sizes and apply median filtering on them. Simulation results, with various images and noise intensities, show that the proposed algorithm has better performance compared with state of the art methods and increases the PSNR value (of the reconstructed image) up to 4 dBs.

Keywords: Noise Removal, Impulse Noise Detector, Image Enhancement.

I. INTRODUCTION

Digital images as the output of different digital cameras and scanners suffer somewhat from different kinds of noise. One of the common types of noise is impulsive noise, in which the difference between current pixels value as its neighboring pixels values are very high. Impulse noise reduction from corrupted images plays an important role in various applications of image processing applications such as image segmentation, object detection, edge detection, compression, etc. Usually a nonlinear filter such as various kinds of median filtering has been used for noise reduction.

In [1], a hybrid method based on cellular automata (CA) and fuzzy logic called Fuzzy Cellular Automata (FCA) in two steps is used. In [2], 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 and tested against different grayscale and color images and it gives better Peak Signal-to-Noise Ratio (PSNR) and Image Enhancement Factor (IEF).

In [3] a method for increase the performance of an ear verification system is proposed, where at first, in a pre-processing step using hybrid-denoising method, the noises are removed from ear images and then the next step these enhanced images are used for verification system. In [4], a two-step method for reduction of impulse noise is presented. At the first step, impulse noise is detected using ANFIS, and at the second step the corrupted noise pixel replaced with new value based on ANN.

Reference [5] proposes an adaptive neuro-fuzzy inference system (ANFIS) based impulse detection method for the restoration of images corrupted by impulse noise. In [6], describes the application of cellular automata (CA) to various image-processing tasks such as denoising and feature detection. The algorithm in [18] uses the mean or median values of the pixels in Von Neumann neighborhood of the processed pixel. Then, the proposed algorithm for detecting and removing of noise is discussed. Simulation results including comparison of them with the related work are presented in section III. Section IV concludes the paper.

II. PROPOSED FILTER

Proposed algorithm for noise detecting and removing, the whole of the image is scanned and processed pixel by pixel. If the current pixel has the maximum value (255) or minimum value (0) then the pixel is considered as noisy pixel. To current value of a noisy pixel, a two-dimensional window centered in that pixel is created. The size of the window is varied according to the number of noise free pixel in the neighborhood of the current pixel.

The resulted value after applying median filter and weighted mean filter on noise-free pixels within window is considered as corrected value of the noisy pixel. Figure 1 shows the proposed algorithm assuming that P is the noisy image and Q is the enhanced image. The steps of the proposed algorithm are illustrated as follows.

Step 1- Create a 2D and 3×3 window centered at P_{ij}, element of this window are more neighbors of the P_{ij};
Step 2- Q_{ij} = -1;
Step 3- Ignore the pixels (in the selected window) with maximum and minimum gray level values;
Step 4- Count is defined as the number of remaining elements in the selected window;
Step 5- If Count == 0 then:
Increase window size (e.g., 3×3 is change to 5×5) and go to Step 3;
else
Med ≜ Median of remaining elements in the selected window;
Step 6- If the size of the window is 3×3 or Q_{ij} == -1 then:

Q_{ij} = Med;
If the number of noise-free pixels is greater than the number of noisy pixels then:
Q_{ij} is considered as improved value for position (i, j);
Step 7- If the size of window is greater than 3×3 or $Q_{ij} > -1$ then:

$$f = \frac{\text{number of noise free pixels in the window}}{\text{total number of pixels in the window}}$$

$Q_{ij} = Q_{ij} \times (1\text{-}f) + Med \times f$
If the number of noise-free pixels is greater than the window's marginal pixels (The pixels in the first and last rows and the first and last columns) then:
Q_{ij} is considered as improved value for position (i, j);
Step 8- If the improved value for noisy pixel (P_{ij}) is not assigned then:
Increase the size of the window and go to Step 3;
Step 9- Repeat the above process for all noisy pixels;

III. SIMULATION RESULTS

In this paper, the proposed algorithm is compared with the several methods for detecting and removing of impulse noise such as Fuzzy Cellular Automata (FCA) [1], Adaptive Neuro-Fuzzy System and Fuzzy Wavelet Shrinkage (ANFISFWS) [3], Neural Network Detector Adaptive Neuro-Fuzzy Inference System (NNANFIS) [4], Neural Network Detector Median Filter (NNDMF) [5], Simple Neuro-Fuzzy Filter (SNFF) [6], Fuzzy Similarity Filter (FSF) [7], Iterative Fuzzy Control based Filter (IFCF) [8], Fuzzy Inference Ruled by Else-action (FIRE) [9], Fuzzy Filter (FF) [10], Progressive Switching Median Filter (PSMF) [11], Signal Dependent Rank Order Mean Filter (SDROMF) [12], Switching Median Filter (SWMF) [13], Impulse Rejecting Filter (IRF) [14], Center Weighted Median Filter (CWMF) [15], Standard Median Filter (SMF) [16], Traditional Cellular Automata with noise detection (TCA) [17].

Table 1. Restoration results in PSNR (dB) of the various filters operating on the (512×512) Lena test images corrupted impulse noise

Methods	IMPULSE NOISE DENSITY (%)							
	10%	20%	30%	40%	50%	60%	70%	80%
FF [10]	31.0	27.6	24.9	22.7	20.3	17.7	14.8	11.7
FIRE [9]	29.9	23.2	18.8	15.5	12.8	10.9	9.3	7.9
IFCF [8]	32.6	29.0	25.0	21.3	18.1	15.6	13.5	11.7
FSF [7]	33.7	28.9	23.0	18.1	14.3	11.5	9.3	7.4
SNFF [6]	30.1	28.4	24.0	21.9	20.0	18.5	16.7	15.2
NNDMF [5]	32.3	32.0	31.5	30.0	28.9	27.7	26.1	23.6
NNANFIS [4]	34.9	31.5	29.1	27.5	25.4	23.2	20.9	18.0
ANFISFWS[3]	29.2	28.2	26.8	23.8	22.0	15.4	12.9	10.8
TCA [17]	32.1	30.5	27.7	25.1	20.1	19.5	16.7	15.0
FCA [1]	35.0	33.5	32.7	31.2	29.2	27.8	26.5	23.7
proposed	43.0	39.0	36.7	34.4	32.7	31.1	29.6	27.8

Subjective performance of the proposed algorithm and reported pervious works are illustrated in Figures 2 and 3, and 6 for 256-gray-level Baboon and Peppers images with 50% impulse noise density. For objective evaluation of the performance of the proposed algorithm, the PSNR metric is used as:

$$PSNR = 10\ \log_{10}\ (\frac{255^2}{MSE}) \tag{1}$$

$$MSE = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}((O(i,j) - Q(i,j))^2}{M \times N} \tag{2}$$

where, $O(i, j)$ and $Q(i, j)$ are the pixel values of original and enhanced image for pixel position at (i, j). M and N are the sizes of the images.

Table 2. Restoration results in PSNR (dB) of the various filters operating on the (512×512) Peppers test images corrupted impulse noise

Methods	Impulse Noise Density (%)							
	10%	20%	30%	40%	50%	60%	70%	80%
FF [10]	29.6	26.1	23.4	21.1	19.0	16.6	14.1	11.3
FIRE [9]	29.7	25.6	20.9	17.0	12.5	10.7	9.4	8.0
IFCF [8]	26.9	22.3	19.5	18.7	17.2	15.5	11.5	10.7
FSF [7]	27.4	25.8	24.6	18.5	17.0	15.3	11.9	9.2
SNFF [6]	24.5	23.1	21.4	19.9	18.4	16.8	15.5	14.2
MNDMF [5]	25.6	24.6	23.4	22.6	21.8	21.1	19.4	18.1
NNANFIS [4]	27.3	26.2	24.9	22.7	19.5	17.6	15.9	13.6
ANFISFWS [3]	28.7	27.3	26.8	25.5	23.2	17.7	14.4	12.1
TCA [17]	31.1	29.3	26.9	24.6	22.0	19.3	16.2	13.2
FCA [1]	32.0	31.5	29.9	29.1	27.2	24.6	20.1	18.2
Proposed	39.8	36.5	34.2	32.5	31.1	29.7	28.5	26.8

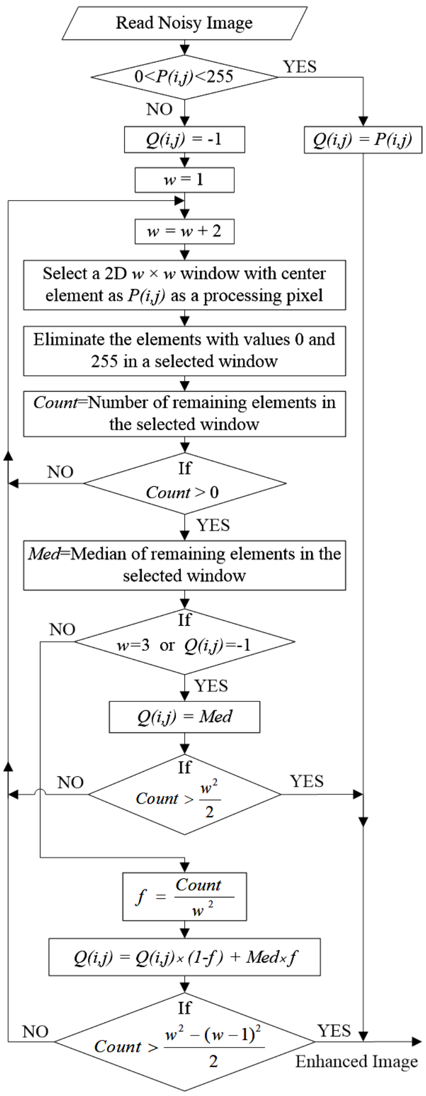

Figure 1. Flowchart of proposed algorithm

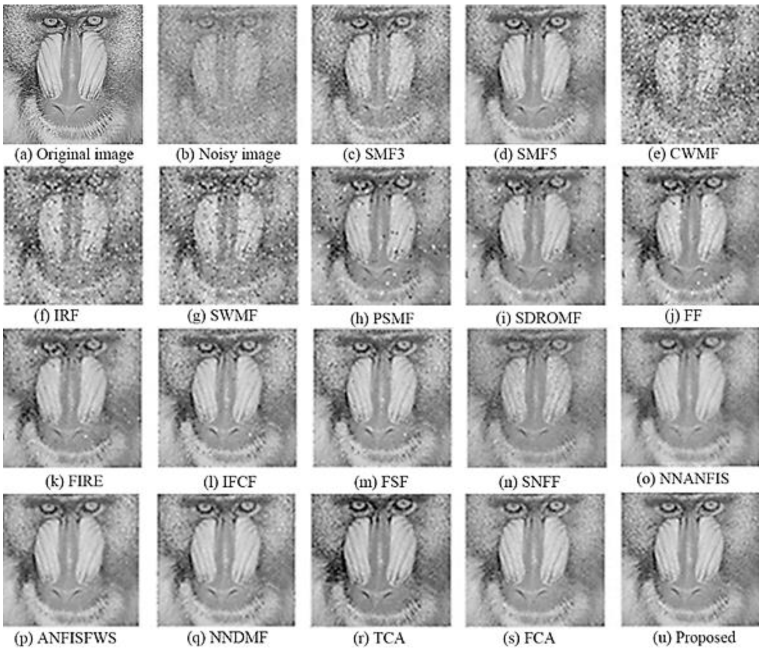

Figure 2. Comparison of the enhanced images for the Baboon by impulse noise density of 50%

Figure 3. Comparison of the enhanced images for the Peppers by impulse noise density of 50%

(a) Original image

(b) Noisy image

(c)

Figure 6. Restoration results of the proposed filter for the Lena image by impulse noise density of 70%

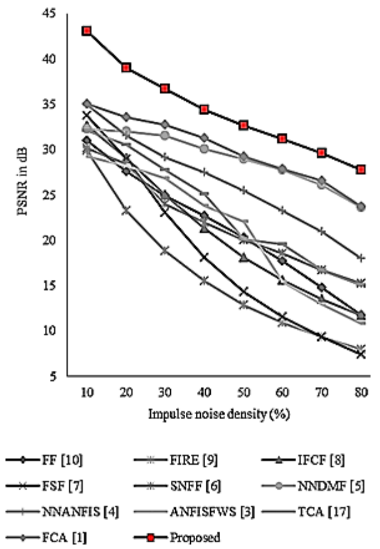

Figure 4. Comparison graph of PSNR at different noise densities for Lena image

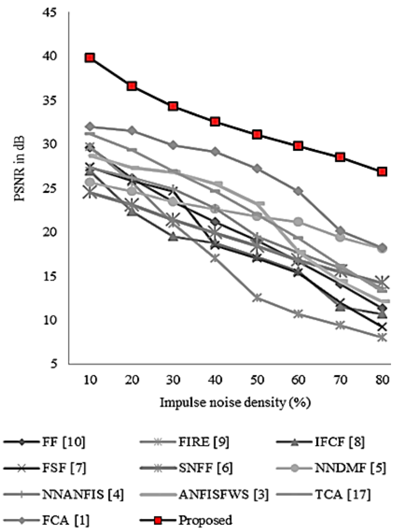

Figure 5. Comparison graph of PSNR at different noise densities for Peppers image

The comparison between the performances of the proposed algorithm and the related works are compared in Tables 1 and 2 for different density values for impulse noise. Tables 1 and 2 results are depicted in Figures 4 and 5. As Figures 4 and 5 show our proposed algorithm's performance is better than other works. The PSNR values of the enhanced images resulted from the proposed algorithm are about 4dB higher than those of other methods.

IV. CONCLUSIONS

In this paper a novel method that is much better than the all-comparable methods for detecting and removing of impulse noise (from images) is proposed. Subjective and objective evaluations on different images with different noise densities show the superiority of the proposed method over the related recent works in the field. The enhanced images resulted from the proposed algorithm has PSNR values which are about 4 dB higher than those of other methods.

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