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Efficient solution to remove impulse noise with high density in color images based on locative-adaptive processing and butterworth frequency filter

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ABSTRACT

Deleting unwanted disturbances such as types of noise and improving the quality of the image, considered as the essential challenge in the research. In this study, by using the locative-adaptive processing and Butterworth frequency filter, an innovative method for detection and removing of impulse noise was presented while maintaining important information such as edges and texture image which includes new algorithms for the detection of impulse noise, high-density and high-density proposed a new filter is to delete impulse noise. The results obtained from tests on noisy images have been evaluated with accurate quantitative and qualitative criteria, such as PSNR. Visual results of the proposed methods, represents the texture and edge detection and noisy image quality improvement compared with existing algorithms.

Keywords*: Image Processing, impulse noise, noisy image quality improvement.*

1. INTRODUCTION

The noise is an unwanted signal that causes interference, change or destroy the original signal and finally causing the disorder. Noise affects in the measurement of the output values of the system, so that it is different from the real amount with value recorded in output. One of the most important types of noise can be pointed to impulse noise that occurs as irregular and discontinuous. Impulse noise on digital images is in the form that the intensity difference noisy pixel by around pixels differs very much. Improvement of damaged image with impulse noise is done by various methods such as filters based on median or nonlinear filters, but these methods lead to image important information removing such as edges and texture. The methods based on soft computing such as filters based on fuzzy logic contains complexity and high computational fees. Setting the parameters in these methods are problematic and obtaining the purpose is difficult.

From the methods for impulse noise removing and image quality improvement it can be mentioned to switching filters such as GLAM [4], BDND [5], OCS [6], FSM [7], EEP [8], SAWM [9], CNDSM [10], NAFSM [11], NAGM [12]and DNLM [13]. In [14] provided the spectrum gradient combined based on a two-stage method for the impulse noise removing. In [15] provided adaptive two-stage median filter (ATSM) for noise removing. The algorithms based on median filter have simple structure and fast run time. the disadvantages of methods based on median filters that if the image contain high-density noise, these filters are not able to detect noisy pixels from non-noisy pixels, and leads to the image important information removing such as edges. [4,7,9,10,14].

In the following sections, we review the related studies in the field of noise removing and the proposed method will be presented in the third section. The simulation results are presented in the fourth Section. The fifth section contains conclusions.

2. RELATED WORK

One of the most important problems in the image processing is the damaged image improvement by impulse noise that is done by different methods including filters based on the median. In relation with salt and pepper noise filtering, median filter is used as a nonlinear filter. The median filter can delete point noises or separated liner noise, while the image edges will not change. One of the disadvantages of the median filter is when the image accepts noise of a threshold higher than 60%. In this case, filter is not able to detect noisy pixels from non-noise pixel and therefore decreases the filter performance. To overcome this problem, the median filter has been improved. Several algorithms have been proposed to median filter improvement.

In [16] presented filter MDBUTMF to recover the impregnated images to impulse noise. In the filter MDBUTMF, in images with Gray levels with intense [0255], firstly the noisy image pixels in order to line by line processed from beginning to end. A two-dimensional window 3×3 in the center of each pixel is created. If the pixel value is something other than 0 or 255, as the real value of pixels be known and will not be processed. If all values of the window was 0 or 255, the average of window values replaces the current value of the pixel, Otherwise the values 0 and 255 have been removed from the windows and remaining values Median placed in the current pixel. These operations will continue to scan the whole picture.

In [17] to remove the impulse noise in images with gray levels of intensity [0255], the noisy image pixels to be processed line by line from beginning to end. A two-dimensional window5 × 5 created in the center of each pixel and to neighbors of each pixel is assigned a specific weight. Variable count 1 and count 2 to hold the number of noisy pixels in the neighborhood of the current pixel is taken up, so that if any of the neighbors {NW, N, NE, W, E, SW, S, SE} have value of 0 or 255, then added to count1. If any of the neighbors {N^2, S^2, E^2, W^2, $NE^{2,}$ SW^2, NW^2, SE^2} have the value of 0 or 255 then added to count2.

T1 and T2 are constant parameters that defined by the user.

If T_1>count1 and T_2>count2 then, there is noise.
If T_1<count1 and T_2>count2 then, there is noise.
If T_1>count1 and T_2<count2 then, there is noise.
If T_1<count1 and T_2<count2 then, there is no noise.
If the current pixel was determined noisy:

1- If in the window5 × 5, the number of pixels without noise was greater than 3, then the without noise values median of window is considered for the current pixel.
2- Otherwise, the values mean of window is considered for the current pixel.

In [18] if in the noisy image, the current pixel value was 0 or 255 then value median of window other than 0 and 255 is calculated. If there was the median, median value will replace the current pixel. Otherwise, the window size will be larger. Windows grow up continues to the maximum size sets by the user. If the window size reach to the possible maximum extent and the median value other than 0 and 255 could not be found, if the number of values 0 was more than the threshold values set by the user, 0willreplace the current pixel. If the number of values 255 was more than the threshold values set by the user, 255 will replace the current pixel.

In [1] a simple and efficient method to delete impulse noise is presented in two stages. In the first stage, after applying a median filter, deletes the noisy points with low dispersion. In the second stage of the algorithm, the noisy points with high-density that the filter in the first stage was unable to correct them, puts under the other median filter. In the second stage of the algorithm, particle collective intelligence is used to find the remaining noisy points.

The presented algorithm In [1] that was named PSOMF works as follows: firstly the output of the standard median filter 3 × 3compares between the nearly points to0 and nearly to 255 and the points that are between the two interval, left untouched and the rest points (where the median filter 3 × 3 has failed to correct them) will be replaced using by median filter 5 × 5.

In [2], in order to deletes the impulse noise, presented a two-step method in the form of identifying and replacing the noisy points. In the first stage, the noisy point detected using by a leading neural network with Reverse publication and the second stage, with the knowledge of the noisy point, the new value is replaced by a two-dimensional cellular automata.

In order to identify the noisy point has been used a leading multi-layer artificial neural network with backward error publication method. The network consist of 3 layers is considered. Input layer is corresponding with the number of neighborhood points and the target point and output layer is corresponding with central point. But the number of appropriate nodes in the median layer according to the accuracy of results is obtained in the number of variable nodes in the network structure in a several test sample. After the neural network training, the network with acceptable accuracy will be able to detect noise.

In [3] a new neural-fuzzy filter to impulse noises deleting of image is presented. This filter is composed of two parts. In the first part using by a decision criterion, specified the noisy pixels and in the second part using by healthy pixel and with the help of neural-fuzzy network ANFIS that trained by this pixels, noisy pixels of image are reconstructed. In [3], the type of shock pulse is a general accumulative noise. Since the impulse noise has values that are difference in terms of light intensity of their surrounding pixels, the method used in [3] contains the noise with constant value.

3. PROPOSED METHOD

In the first phase of the proposed algorithm, our aim is to detect the impulse noise. Since the impulse noise for the highest and lowest intensity exist in the noisy image, we receive highest and lowest threshold as input parameters in the first step.

The lowest threshold as input parameters receives from the user =T_1

The highest threshold as input parameters receives from the user =T_2

Then throughout noisy image scanned and processed pixel by pixel. We consider the two dimensional array P to store modified values of noisy image. If the current pixel contains the value except the highest and lowest threshold level, these pixels is detected as actual value of image and its value maintained without changes and stored in P. Otherwise, It is possible that the value of the pixels

have noise and should be analyzed using the proposed algorithms.
To correct the pixel values that are likely to be noisy, at the first step, a two-dimensional window 5×5 is formed centered at the current pixel by pixel values in the neighborhood of von Neumann, as showed in Figure 1.

		P(i , j-2)		
	P(i-1, j-1)	P(i , j-1)	P(i+1, j-1)	
P(i-2, j)	P(i-1, j)	P(i , j)	P(i+1, j)	P(i+2, j)
	P(i-1, j+1)	P(i , j+1)	P(i+1, j+1)	
		P(i , j+2)		

Fig.1 matrix 5×5 with pixel values in the neighborhood of Von Neumann

equal size array with image P whose name is HP. cut-off frequency at a distance of D_{02} of the quadrangle center of frequency is received as input parameters for Butterworth high-pass filter.
By separating the edges of impulse noise and applying values of the detected edges to image, we can enhance the quality of noisy image. To determine the validity of the edges of acts Butterworth high-pass filter, we use the sobel edge detection pattern. The actual edge of noisy image detected by applying a Butterworth high-pass filter and using the sobel detection pattern, and modified the HP values.
Finally, to improve the quality of noisy image, the actual edges of noisy image of applying Butterworth high-pass filter (HP) combined with the result of Butterworth low-pass filter (LP). Figure 4 shows the structure of the proposed algorithm and how to combine the output of the HP and LP.

1.3. THE PROPOSED ALGORITHM FOR NOISE IMPACT IS AS FOLLOWS:

First step: receive the highest and lowest threshold as input parameters.
T_1= Catch the lowest threshold from the user as input parameters
T_2= Catch the highest threshold from the user as input parameters
Second step: defined the two-dimensional array P for storing the corrected values of noisy image.
Third step: repeat the below steps for the all values of noisy image pixels.
Fourth step: if the current pixel value except the highest and lowest threshold, then this pixel is known as the actual value of image and its value is unchanged and stored in P.
Fifth step: If the current pixel value is the highest and lowest threshold, then the value of this pixel, the noisy is considered.
Sixth step: repeat the below steps for the pixels with noisy values.
Seventh step: create the two-dimensional window 5×5 by centered at the noisy pixel with pixel values in the neighborhood of von Neumann.

If all the values in the window are less than of T_1 and more than of T_2 Then mode of all values in the neighborhood von Neumann window 5×5 is replaced to the current pixel. Otherwise, all of the window Values which are less than T_1 and more than T_2 are overlooked and mean of the remaining values in the window, replace the current pixel's value.
In the second phase of the proposed algorithm, the modified image in the spatial domain, investigated in the frequency domain. Processing in the frequency domain includes the modification of the Fourier transform of the image and then calculated the inverse transform to obtain the result.
In the low-pass filter of two-dimensional Butterworth, D_{01} is the cutoff frequency and is received as input parameters.
Appling the Butterworth low-pass filter in the frequency domain causes eliminating impulse noise and image softening. But, the significant disadvantage of this filter is to remove some of the edges and texture of image. In the second phase of the proposed algorithm, we offer a method that after removing the impulse noise of the image, the edges and texture of image retained.

P_1	P_2	P_3
P_4	P_5	P_6
P_7	P_8	P_9

Fig.2 windows 3×3 of image

$$x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

Fig.3 edge detection Patterns the Sobel method [19]

To remove the few remaining impulse noise, improved image in spatial domain of Butterworth low-pass filter cross in the frequency domain and the result stored in the equal size array with image P whose name is Pluto detect the edges of image Q, image P of Butterworth high-pass filter crossing in the frequency domain and the result stored in the

Otherwise: LP(i,j) = Enhance(i,j)
Fifteen Step: if all of the noisy image scanning does not ended, then go to Step Fifteenth.
Sixteenth Step: the two-dimensional array Enhance send to output as final modified image.
Seventeenth Step: end.
For impulse noise with high density (80% or 90%) suggested the window 7×7.

4. SIMULATION RESULTS

Tables 1 and 2 shows the comparison of the performance of the proposed algorithm and above mentioned methods with measure PSNR for the Lena and Baboon standard image with gray levels in size 512×512 with [0,255] intensity with impulse noise density 10% to 80%. The evaluation of Tables 1 and 2 values show the better performance and superiority of the proposed algorithm to other methods. The graph of proposed algorithm performance in comparison with the mentioned algorithms with test on the Lena and Baboon standard images with impulse noise density 10% to 80% in Figures 5 and 6 represent the superiority of the proposed algorithm to mentioned methods. The visual results of proposed algorithm with experiments on the standard images with the impulse noise density 60%, 70%, 80% and 90% are shown in the figure 7, 8, 9 and 10. According to the simulation results, it can be observed the better performance and superiority of the proposed algorithm compared to other methods.

Eighth step: If all of the values in the window, less than T_1 and more than T_2, then:
The mode of all of the values in the neighborhood of von Neumann window 5×5 replaced the current pixel.
Otherwise:
All of the values less than T_1 and more than T_2 from made up window will be ignored and average of remaining values in the window replaced by the current pixel.
Ninth step: if the whole image scanning is not ended, then go to Fourth step.
Tenth Step: P_1=P
Modified Image in the spatial domain pass of the Butterworth low-pass filter in the frequency domain and save the result in the same size array with image P_1 called LP.
Step Eleventh: P_2=P
Modified Image in the spatial domain pass of the Butterworth high-pass filter in the frequency domain and save the result in the same size array with image P_1 called HP.
Twelfth Steps: two-dimensional array Enhance defined to final storing the noisy image modified values in the frequency domain.
Thirteenth Step: repeat the below steps for all of the noisy image pixels values.
Fourteenth Step: According to the sobel edge detection pattern, pixel P (i,j) is the edge?
Create the window w with dimensions 5×5 with centered by HP(i,j) and the corresponding values in the neighborhood of von Neumann.
W + LP(i,j) = Enhance(i,j)

Table 1: Compare the results of the proposed algorithm and mentioned methods with criteria PSNR, for the Lena standard images in the gray levels in size 512×512 with intensity [0,255] with impulse noise density 10% to 80%

Methods	***Noise ratio***							
	10%	***20%***	***30%***	***40%***	***50%***	***60%***	***70%***	***80%***
Noisy	15.5	12.4	10.6	9.5	8.5	7.7	7.0	6.4
FSF [25]	33.7	28.9	23.0	18.1	14.3	11.5	9.3	7.4
SNFF [24]	30.1	28.4	24.0	21.9	20.0	18.3	16.7	15.2
NNDMF [23]	32.3	32.0	31.5	30.0	28.9	27.7	26.1	23.6
NNANFIS [22]	34.9	31.5	29.1	27.5	25.4	23.2	20.9	18.0
ANFISFWS [21]	29.2	28.2	26.8	23.8	22.0	15.4	12.9	10.8
FCA [20]	35.0	33.5	32.7	31.2	29.2	27.8	26.5	23.7
Proposed	42.0	38.3	35.8	34.1	32.3	31.3	30.3	28.1

Table 2: Compare the results of the proposed algorithm and mentioned methods with criteria PSNR, for the Baboon standard images in the gray levels in size 512×512 with intensity [0,255] with impulse noise density 10% to 80%

Methods	***Noise ratio***							
	10%	***20%***	***30%***	***40%***	***50%***	***60%***	***70%***	***80%***
Noisy	15.6	12.6	10.8	9.5	8.6	7.8	7.1	6.5
FSF [25]	23.0	22.1	20.0	17.1	14.3	11.9	9.8	8.0
SNFF [24]	30.9	28.2	26.2	24.3	22.4	20.8	19.2	17.8
NNDMF [23]	22.7	22.6	22.5	22.3	22.0	21.6	21.2	20.5
NNANFIS [22]	31.1	28.0	26.1	24.5	23.0	21.5	19.6	17.2
ANFISFWS [21]	28.7	23.8	23.0	22.1	19.9	18.1	15.4	13.9

FCA [20]	31.2	28.5	27.2	24.6	23.3	22.3	21.5	21.0
Proposed	37.0	33.4	31.5	29.0	27.3	26.3	25.3	23.7

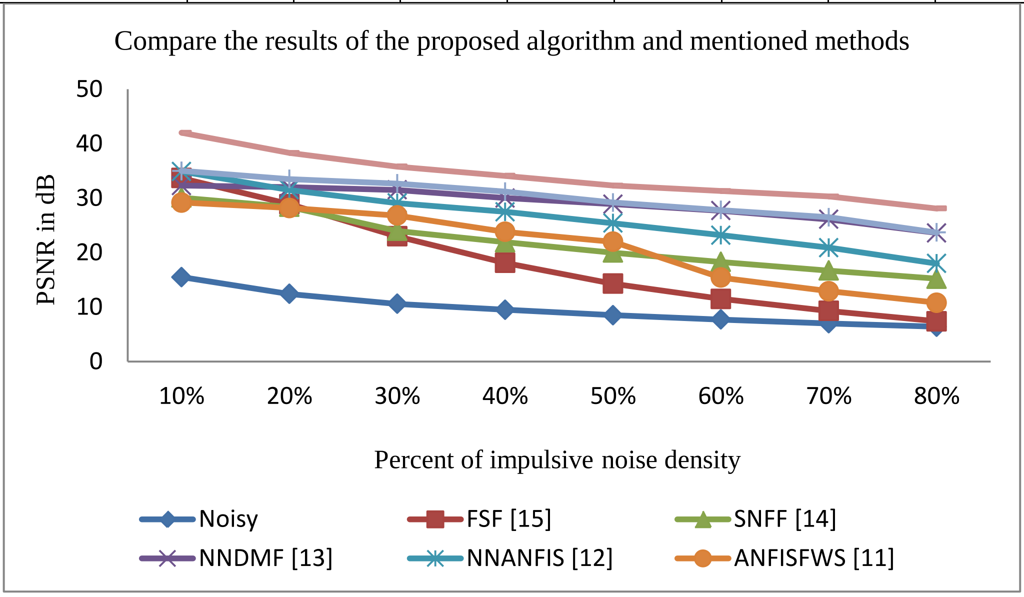

Fig.4 the proposed algorithm performance in comparison with mentioned algorithm with test on the Lena standard images with impulse noise density 10% to 80%

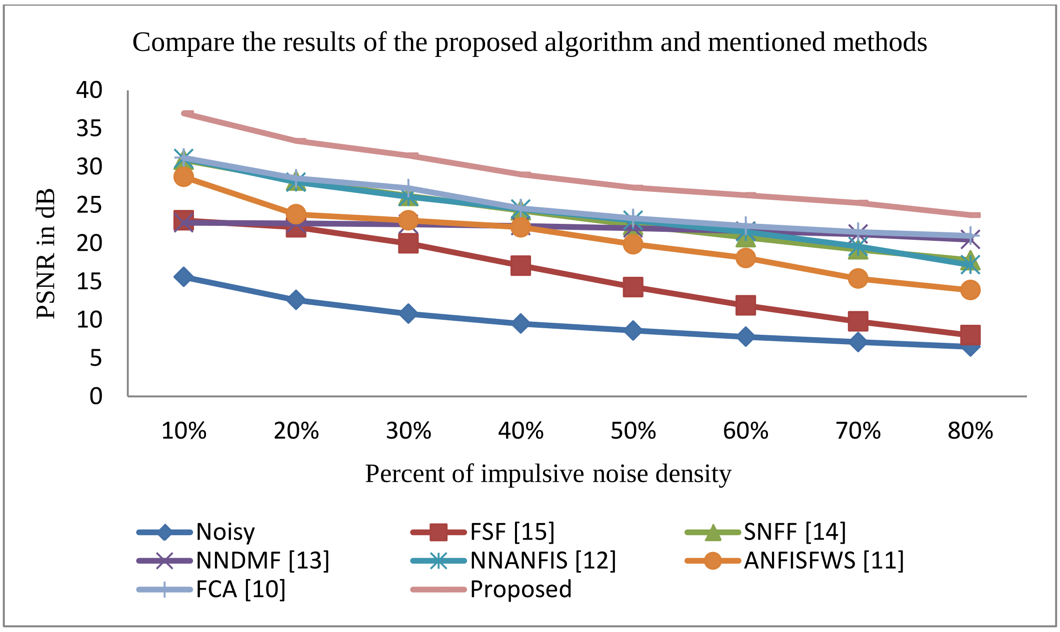

Fig.5 the proposed algorithm performance in comparison with mentioned algorithm with test on the Baboon standard images with impulse noise density 10% to 80%

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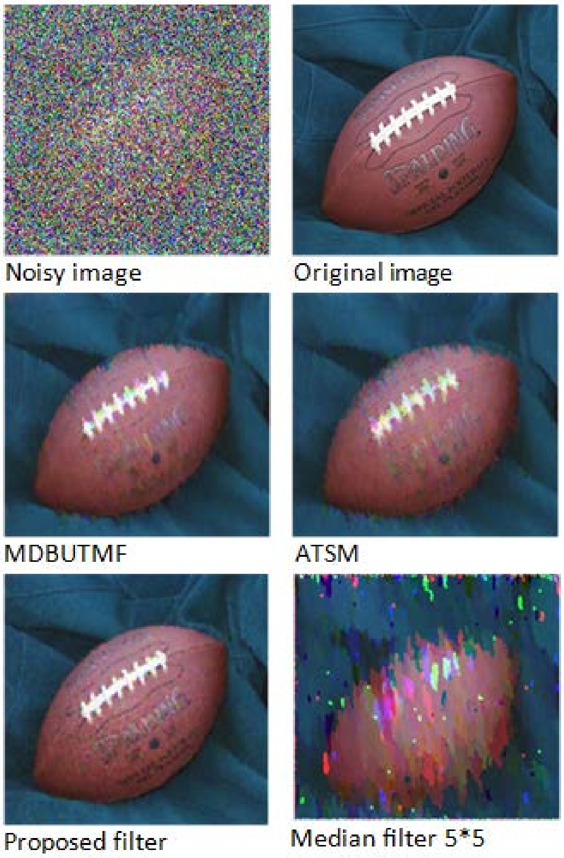

Fig.6 Compare the results of the proposed method with related methods with noise density of 80%

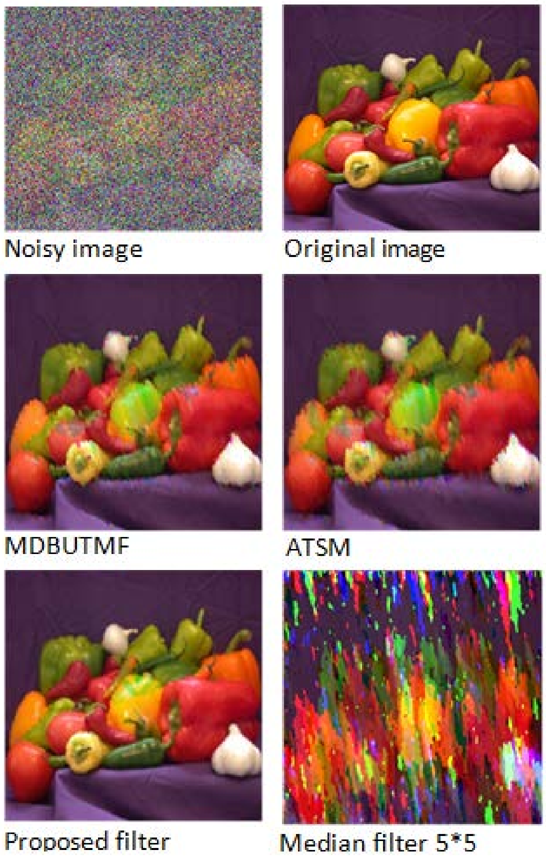

Fig.7 Compare the results of the proposed method with related methods with noise density of 90%

5. CONCLUSIONS AND SUGGESTED FOR FUTURE WORK

In this paper, by using locative-adaptive processing and Butterworth frequency filter, an innovative method for impulse noise removing and detection is presented while image important information protected such as edges and texture of image that includes the following:

Introduce a new algorithm for the detection of high-density impulse noise through appropriate threshold level suggestion and image locative processing.

Suggest a new filter for the removing of high-density impulse noise through introducing the new filter by Butterworth locative and frequency processing.

The results of tests on noisy images have been evaluated with quantitative and qualitative measures most accurate such as PSNR. Visual results of the proposed methods, shows the texture and edge detection and noisy image quality improvement in comparison to the existing algorithms. The values PSNR of the modified image, on average, 1dB increased than previously reported tasks.

The following methods are recommended for future work:

Noise smart detection in impregnated images to impulse noise.

Impulse noise smart removing of impregnated images to impulse noise.

Image important information protection such as texture and edge with smart methods.

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