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A Case Study to Improve the Quality of Median Filter

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Abstract
The median filter is used to reduce the effect of noise, but it treats all pixels, whether they are noise points or not, which negatively affects many non-noise values in the digital image, and the negative effect increases as the noise ratio increases. In order to get rid of some of the disadvantages of the median filter, we will present in this research paper a detailed study that works on treating the unaffected and infected pixels so that this treatment leads to improving the performance of the filter by raising the values of the quality factors of the filter. The improvements added to the median filter will raise the efficiency of the noise reduction process, especially for high noise ratios.

Keywords: Noise, noise ratio, median filter, PSNR, quality factor, MSE, improvements.

1- Introduction
Digital images, whether color or grayscale [1-5], are used in many computer applications, and many of these applications require that the digital image be clear and free of noise. Digital images are affected by different types of noise, including salt and pepper noise, as this change leads to distortion of the image and changing some of its basic characteristics, which makes it difficult to process the digital image for the specific application. When a digital image is affected by salt and pepper noise, the values of some pixels will change to zero or 255[6-10]. The number of pixels whose values have changed depends on the noise ratio. As the noise ratio increases; the number of pixels whose values have changed increases and the value of the negative impact on the digital image increase [6-10].

One of the filters used in noise treatment of salt and pepper type [11], [12]is the median filter, this filter acts by taking the pixel's values included in the filter window and replacing the associated pixel value with the sorted window center as show in figure 1.

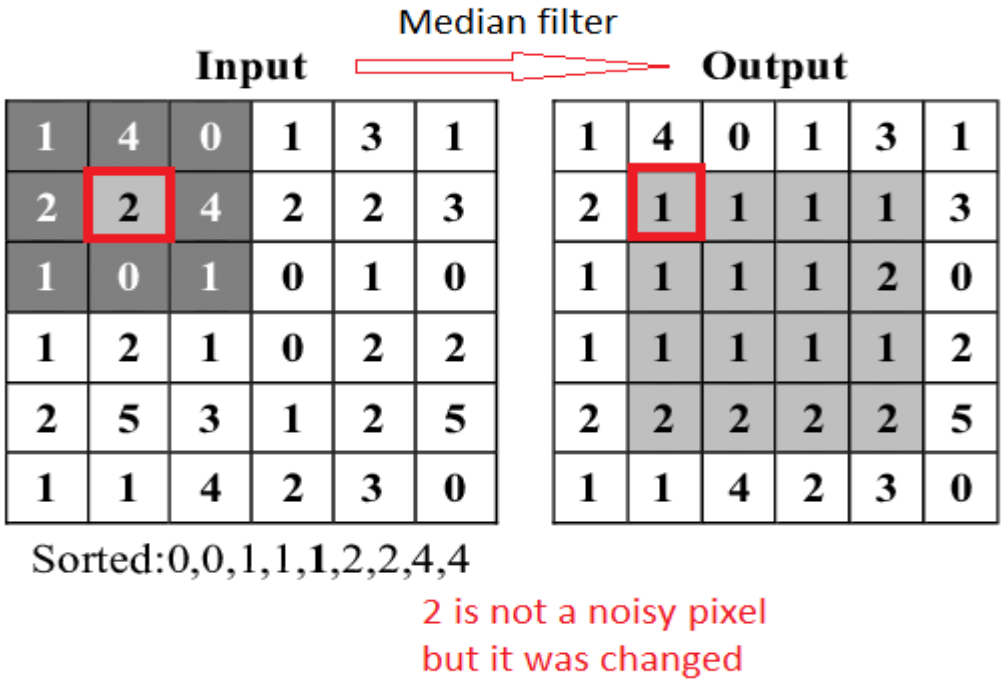

Figure 1: Median filter manipulation

When dealing with the mediator candidate, it is necessary to pay attention to the following, which are considered among the disadvantages of this filter [13-17]:

- The median filter is good to eliminate salt and pepper noise when the noise ratio is low [21-27].
- Increasing the noise ratio will decrease the quality factor PSNR (peak signal to noise ratio) between the clear and the denoised images (at the same time MSE (mean square error) will increased), thus the quality of the cleared image will be negatively affected (quality factors can be calculated by equation 1 and 2), so it is not recommended to use median filter for high noise ratios (see figures 2 and 3) [18-20].

$$MSE_x = \frac{1}{N}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[S(i,j) - R(i,j)]^2 \ , N = m * n \quad (1)$$

S and R are two images

Total MSE for color image

$$MSE_t = MSE_r + MSE_g + MSE_b$$

Calculate PSNR

$$PSNR = 10 * \log_{10} \frac{(MAX_I)^2}{MSE_t} \quad (2)$$

Figure 2: Using Median filter to eliminate low noise ratio noise

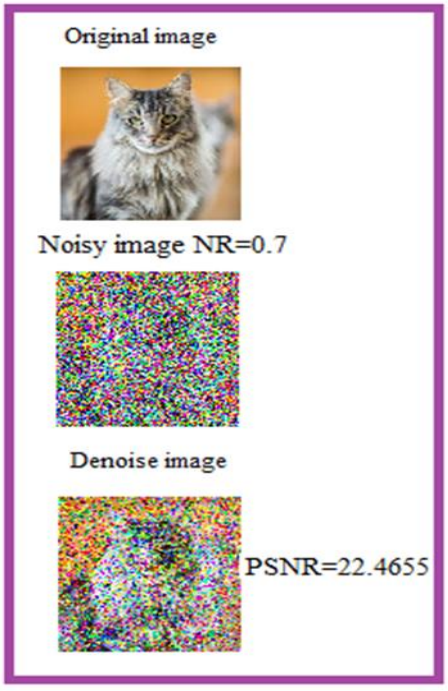

Figure 2: Using Median filter to eliminate high noise ratio noise

2- Cases study of median filter

1- Case 1:

The pixel under processing is not a noisy pixel (greater than zero and less than 255), see figure 3:

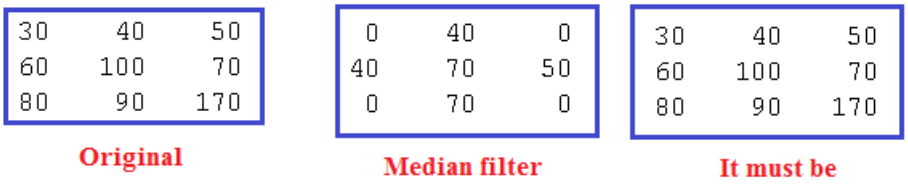

Figure 3: Not noisy pixel

The pixel value was changed to mean value using median filter, the improvement here is to keep the pixel value without change.

2- Case 2:

The pixel under processing is not a noisy pixel and it is surrounded by zero noisy pixels (see figure 4):

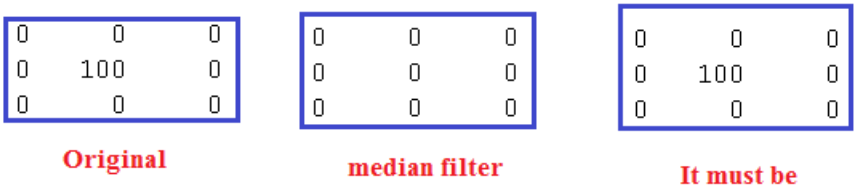

Figure 4: Not noisy pixel surrounded by 0 noisy pixels

The pixel value was changed to mean value using median filter, the improvement here is to keep the pixel value without change.

3- Case 3:

The pixel under processing is not a noisy pixel and it is surrounded by noisy pixels with value =255(see figure 5):

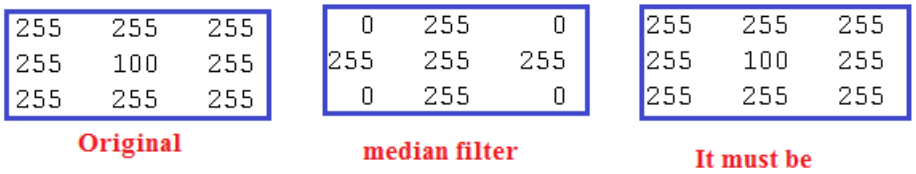

Figure 5: Not noisy pixel surrounded by 255 values noisy pixels

The pixel value was changed to mean value using median filter, the improvement here is to keep the pixel value without change.

4- Case 4:

For the sorted window, and if the condition in figure 6 is satisfied then the pixel value must equal the mean

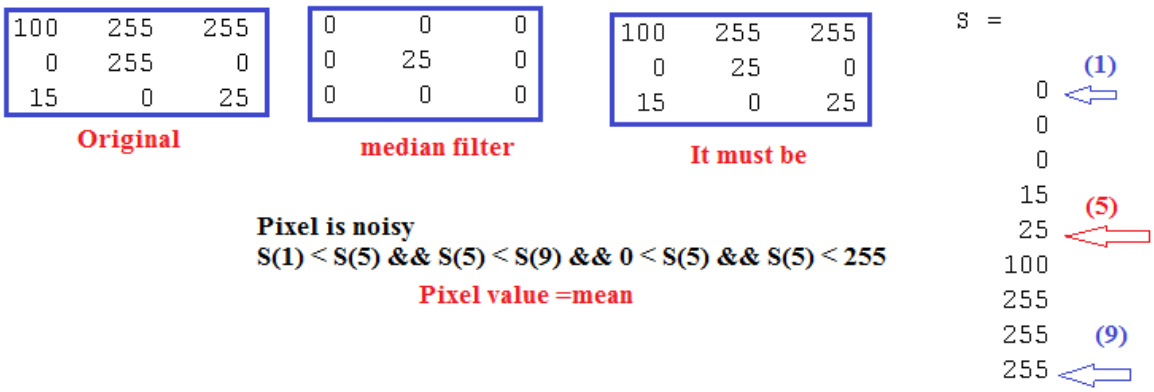

Figure 6: Case 4

5- Case 5:

For the sorted window, and if median value =0 (see figure 7), keep the pixel value without change.

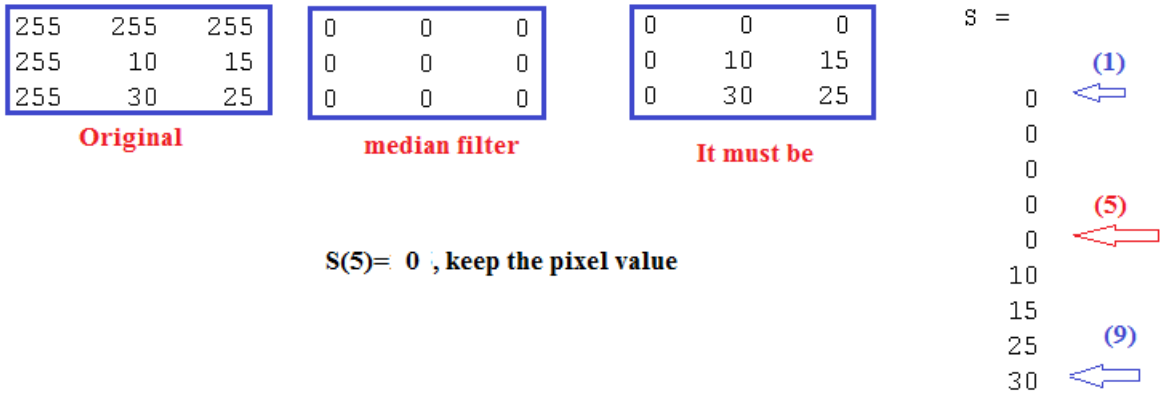

Figure 7: Case 6

6- Case 6:

For the sorted window, and if median value =255 (see figure 8), keep the pixel value without change.

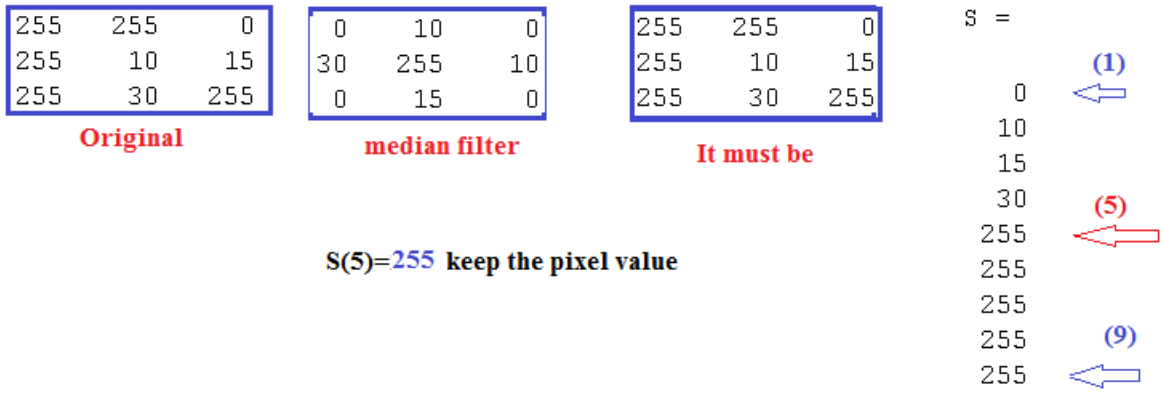

Figure 8: Case 7

3- Implementation and experimental results

An improved method which takes the above mentioned cases was programmed using matlab, a big image with size equal 6119256 bytes was affected with salt and pepper noise using various values of noise ratios, figures 9 show the de-noised images using the traditional mean and the improved methods:

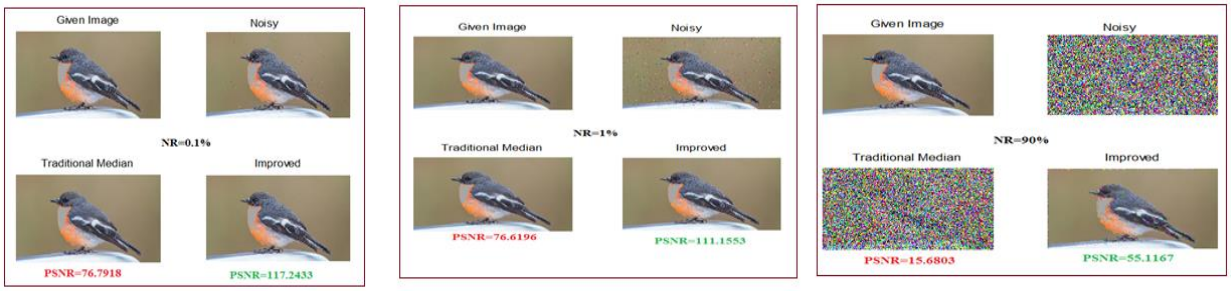

Figure 9: De-noising big image

Another image with smaller size (size = 151875 bytes) was affected by salt and pepper noise using various noise ratios, figure 10 shows the outputs applying median and improved filters

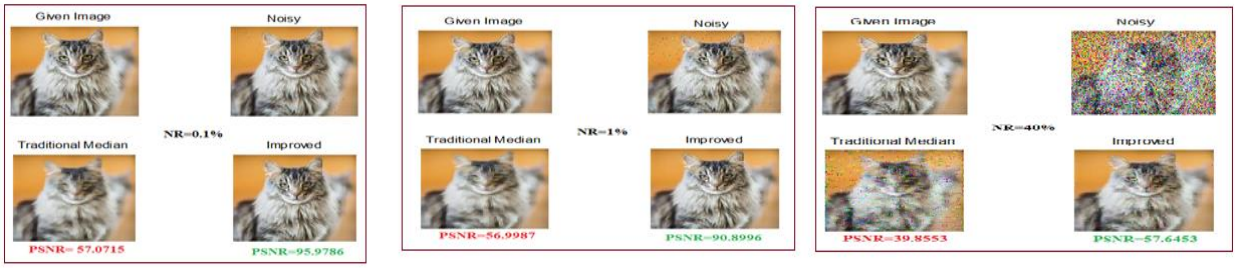

Figure 10: De-noising small image

The improved method was implemented using 3 images (big size, medium size and small size), these images were affected by salt and pepper noise with various values of noise ratios, the quality parameters were calculated, and the obtained results are shown in tables 1, 2 and 3:

Table 1: Quality parameters after removing small ratio noise

NR %	Small image, image size=151875 byte		Big image, image size=6119256 byte	
	Median PSNR	Improved PSNR	Median PSNR	Improved PSNR
0.1	57.0717	95.9387	76.7898	117.2663
0.2	57.0703	95.6667	76.7805	116.2536
0.3	57.0602	94.9448	76.7603	115.7994
0.4	57.0421	93.9571	76.7367	115.0546
0.5	57.0267	93.3718	76.7198	114.1371
0.6	57.0206	92.5501	76.7065	113.5871
0.7	57.0202	92.4798	76.6755	112.8292
0.8	57.0124	91.6459	76.6734	112.3650
0.9	56.9863	91.5361	76.6480	111.9018

Table 2: Quality parameters after removing medium ratio noise

NR %	Small image, image size=151875 byte		Big image, image size=6119256 byte	
	Median PSNR	Improved PSNR	Median PSNR	Improved PSNR
1	57.0046	91.4873	76.6185	111.5379
2	56.8873	87.6187	76.4470	107.2266
3	56.6564	84.1812	76.2580	104.2941
4	56.6369	82.7448	76.0150	101.7611
5	56.3642	80.1221	75.8401	100.0923
6	56.1930	79.2371	75.5789	98.3327
7	56.0929	77.9581	75.2810	96.8797
8	55.8423	76.8905	74.9671	95.3910
9	55.4202	74.8461	74.7046	94.3752

Table 3: Quality parameters after removing high ratio noise

NR %	Small image, image size=151875 byte		Big image, image size=6119256 byte	
	Median PSNR	Improved PSNR	Median PSNR	Improved PSNR
10	55.3026	74.3472	74.3129	93.2460
20	51.6400	66.5954	66.9679	85.6004
30	46.4365	61.4749	55.1532	80.5261
40	39.2825	56.9698	44.4324	76.3118
50	32.7429	53.6216	35.7094	72.6036
60	27.1878	50.2655	28.8758	69.0028
70	22.2285	46.1827	23.4926	65.3367
80	18.0945	42.5987	19.1479	60.9266
90	14.7216	36.8392	15.6840	55.1694

From tables 1, 2 and 3 we can raise the following facts:

- The degree of noise effect on small images is greater, and the distortion is visible, and when the noise ratio is high, the median filter cannot remove the noise, the improved filter enhances the image quality by increasing PSNR and decreasing MSE as shown in figure 11

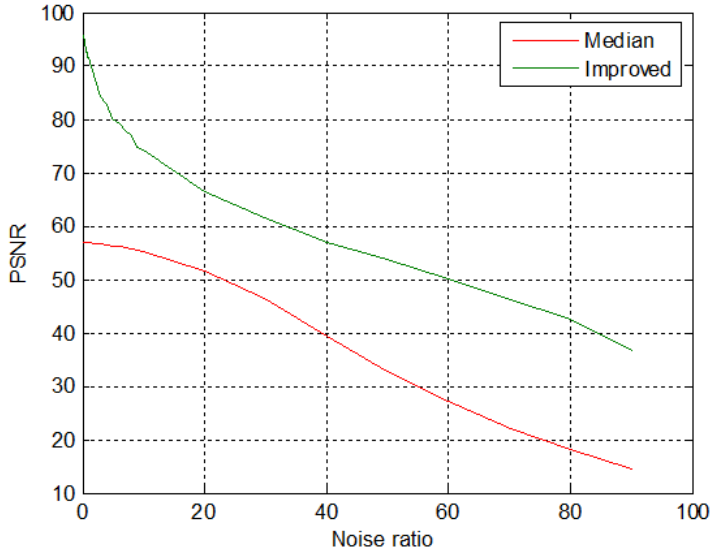

Figure 11: Quality parameter using small image

- When using big images the negative effects of salt and pepper noise decreased, and here the median noise can solve the negative effects of the noise when the noise ratio less than 40%, this percentage will be increased to 90% if we use the improved filter, this is shown in figure 12.

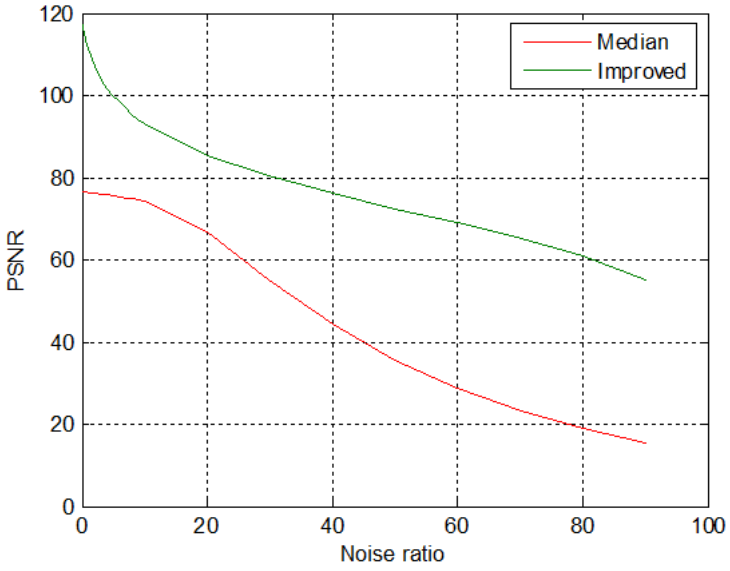

Figure 12: Quality parameters using big image

Conclusion

Median filter was tested using various images with various sizes, various ranges of salt and pepper noise ratios were applied. The same experiments were repeated using the improved median filters. The proposed enhancements can be better eliminate the negative effects of the noise for any image size and with any noise ratio, the improved method can deal with noise with higher noise ratios and it succeed to eliminate the noise even the noise ratio equal 90%.

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