VOL. 18, NO. 4, FEBRUARY 2023 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

IMPROVED MEDIAN FILTER TO ELIMINATE SALT AND PEPPER NOISE IN DIGITAL

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ABSTRACT

Digital images are affected by different types of noise, including salt and pepper noise, which negatively affects the image, changing its features and affecting many of its characteristics, which calls for providing an easy way to remove this noise or get rid of it significantly. In this research paper, a new and simple method of deducting salt and pepper noise will be proposed, tested and implemented. The proposed method will be compared with standard filters such as average and median filters. To prove the effectiveness of the proposed method it will be compared with other popular methods dealing with salt and pepper noise such as SM, DWM, MDWM, MDW, TVW, and TS filters.

Keywords: SAPN, NR, MSE, PSNR, MMF Average filter, median filter, digital filters.

1. INTRODUCTION

Salt-&-pepper noise [11-13] is a form of noise that can be seen sometimes on digital images [7-10]. This noise can be affecting the image as a result of sharpening and sudden disturbances in the image signal. It appears in the image as white and black pixels (255 or 0 values). Salt and pepper noise (SAPN)affects digital image by adding pixels with values 0 and 255, thus will increase the repetitions of these value in the image and it will be reflected in the image histogram as shown in Figure-1.

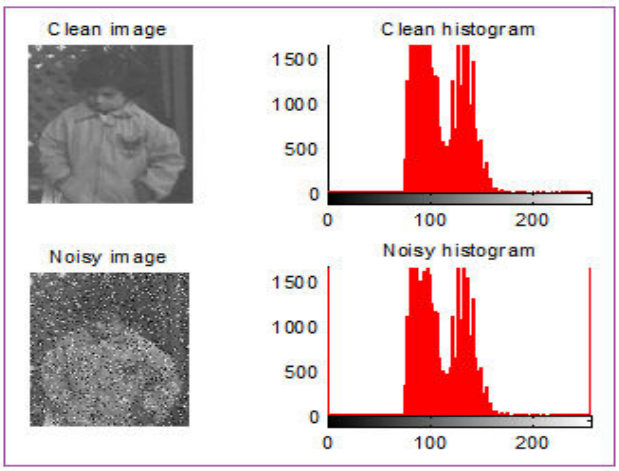

Figure-1. SAPN increases the repetition of 0 and 255 in the image.

The number of added 0s or 255s depends on the noise ratio (NR) [14], increasing the ratio will increase the noise density by increasing the values 0 and 255, as shown in figure 2(ap means affected pixels).

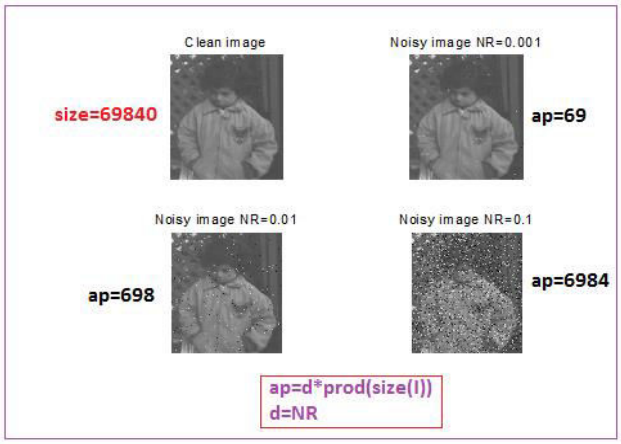

Figure-2. NR effects.

Many methods are used to reduce the negative effects of SAPN; many of them are based on using the linear average filter or median filter. The filters deal with SAPN by manipulating each pixel in the noisy image based on a selected window (3 by 3 usually) and the pixel in the window center will be calculated as shown in Figures 3 and 4.

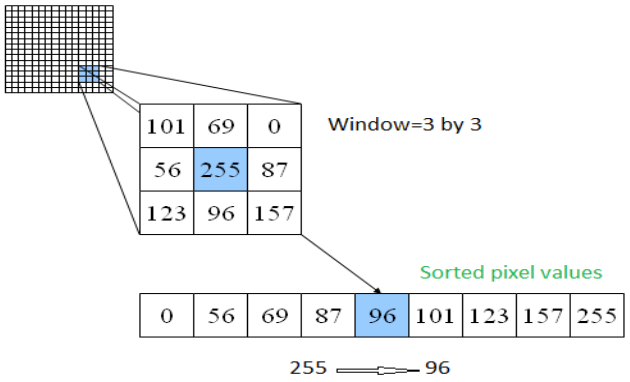

Figure-3. Median filter calculations.

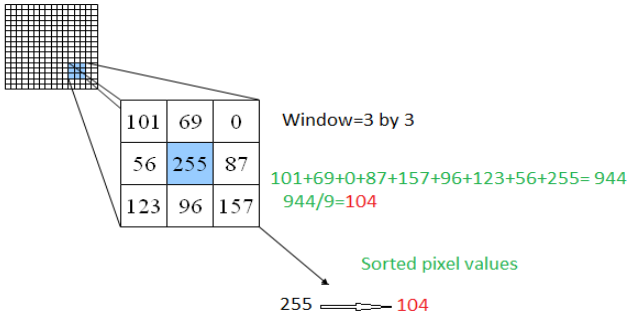

Figure-4. Average filter calculations.

2. RELATED WORKS

Many methods were introduced to remove or reduce the negative effects of salt and pepper noise on digital images. These methods vary in the quality of dealing with noise by giving varying values to the quality parameters: MSE (mean square error) and PSNR (peak signal to noise ratio), the lower the value of MSE is, the better the quality of the de-noised image, while the higher the value of PSNR is, the better the quality of the de-noised image. MSE and PSNR can be equations 1 and 2 [15-17]:

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|f(i,j) - g(i,j)\|^2 \quad (1)$$

$$PSNR = 20\log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right) \quad (2)$$

Where f, g are two images to be compared for quality.

To demonstrate the effectiveness of the proposed modified median filter (MMF) will be compared with the standard median and average filters, it will be also compared with other six popular methods used to reduce salt and pepper noise. These methods are: Two_ stage filter (TSF) [1], switching median (SM) filter [2], the directional weighted median (DWM) filter [3], the modified directional weighted median (MDWM) filter [4], the modified directional weighted (MDW) filter [5] and the three-values-weighted (TVW) filter [6].

3. THE PROPOSED METHOD

The proposed method is based on median filter by adding an enhancement to it, and we will refer to it as the modified median filter (MMF), this method can be implemented applying the following steps:

Step1: Initialization

In this step we have to perform the following tasks:

- Get the noisy image.
- Get the image size (n: rows, m: columns).
- Calculate the index matrix (1 means that the associated pixel does not equal 0 or 255), 0 means that the associated pixel equal either 0 or 255(noisy pixel) (see Figure-5).
- Pad the image by adding extra 2 columns and extra 2 rows.
- Find the pad matrix index.

Step 2: Set i and j to 1.
Step 3: While i<=n do
Step 4: While j<=m do
Step 5: If the associated pixel in the index matrix equal 1, keep the pixel value in the noisy image and continue.
Step 6: Select a window in the pad matrix.
Step 7: If the sum of the window elements equal zero continue.
Step 8: Let the noisy pixel equal the median of the window elements excluding 0 and 255.
Step 9: Increment j.
Step 10: End while.
Step 10: Increment i.
Step 11: End while

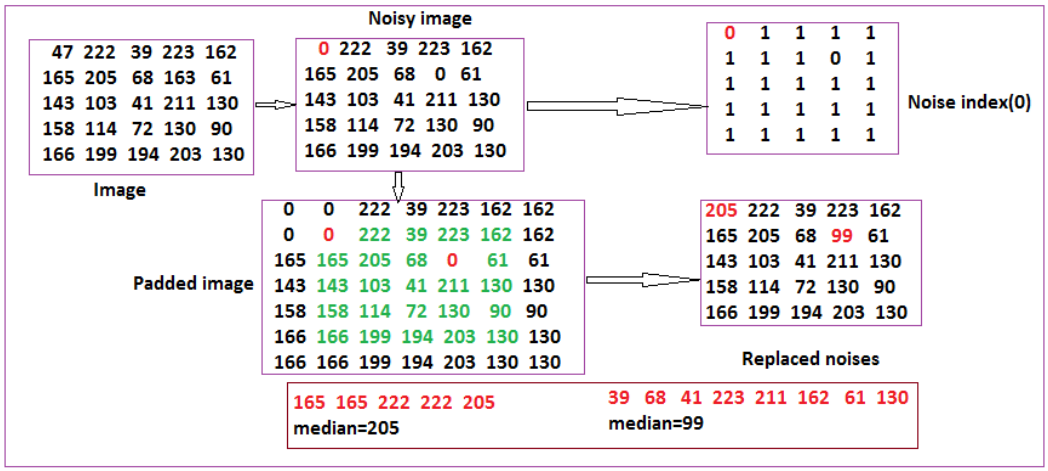

Figure-5. MMF implementation example.

Figure-6 illustrates an example of manipulating MMF comparing with median and average filters

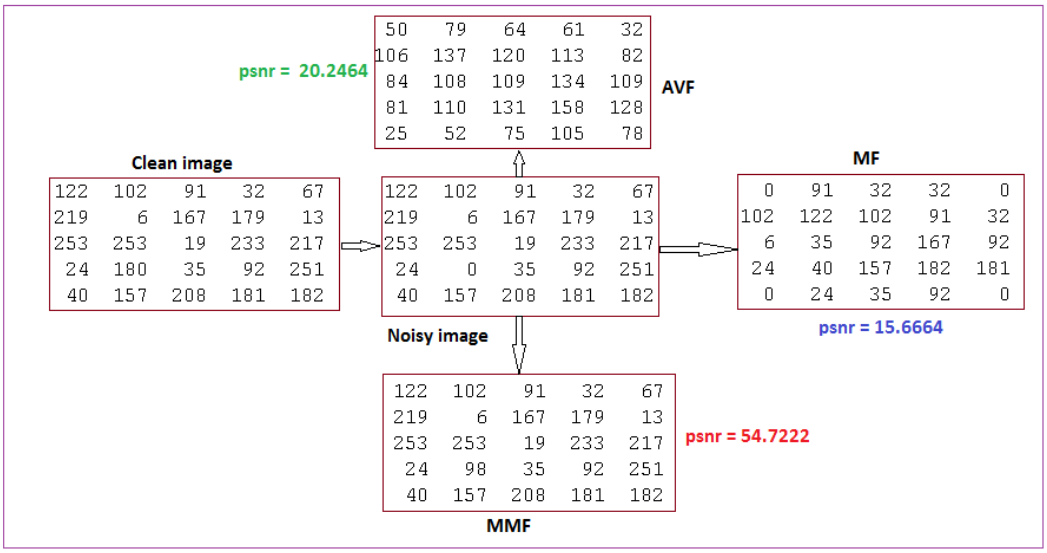

Figure-6. MMF and median and average filters implementations.

4. IMPLEMENTATION AND EXPERIMENTAL RESULTS

The proposed MMF method was implemented using various noisy images with various values of NR, Figures 7 and 8 show some obtained outputs:

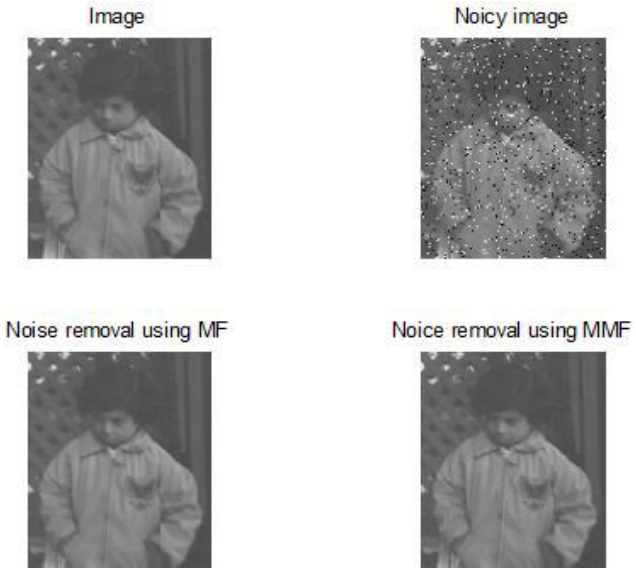

Figure-7. Applying MF and MMF filters with NR=0.05.

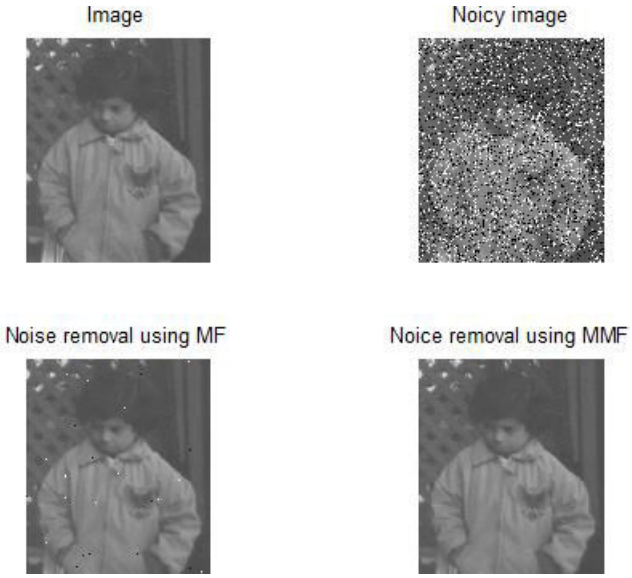

Figure-8. Applying MF and MMF filters with NR=0.2.

Table-1 shows the obtained results applying average, median and the proposed filters using pout.tif image with various values of NR.

From Table-1 we can see that the proposed method gave the best values for MSE and PSNR using any value of NR, this is illustrated in Figures 9 and 10.

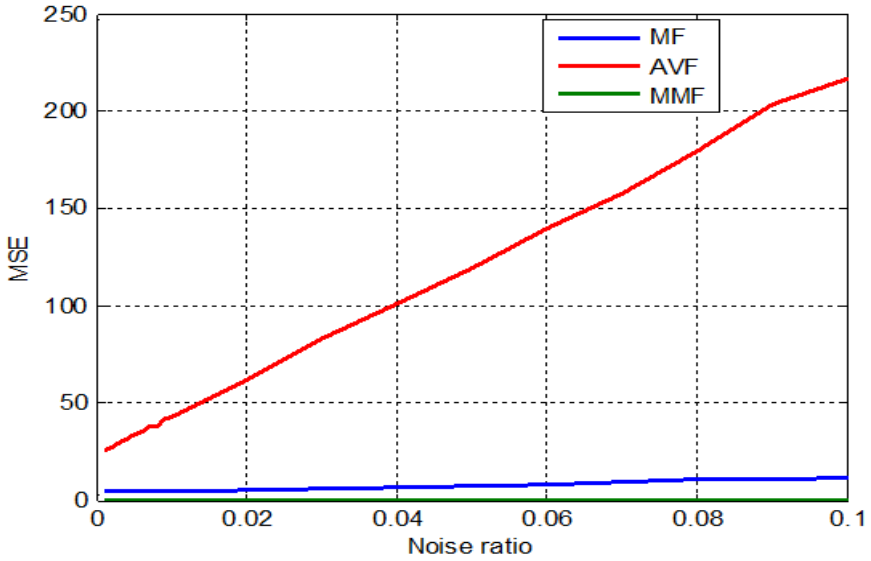

Figure-9. MSE comparisons of AVF, MF, and MMF.

Table-1. Comparison results 1.

Noise ratio	MF		AVF		MMF	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
0.001	4.5744	93.0282	25.8966	75.6918	0.0210	146.8424
0.002	4.4633	93.2741	27.3749	75.1366	0.0082	156.2288
0.003	4.5407	93.1021	29.6006	74.3550	0.0168	149.0823
0.004	4.5163	93.1561	32.0199	73.5693	0.0254	144.9683
0.005	4.5246	93.1376	33.9910	72.9720	0.0318	142.7019
0.006	4.7820	92.5844	35.0195	72.6739	0.0440	139.4587
0.007	4.5628	93.0536	38.0692	71.9279	0.0383	140.8592
0.008	4.6136	92.9429	38.0534	71.8430	0.0306	143.1010
0.009	4.5969	92.9792	41.8174	70.8998	0.0745	134.2046
0.010	4.5210	93.1456	43.3481	70.5403	0.0487	138.4543
0.020	4.9075	92.3253	61.8435	66.9869	0.0873	132.6187
0.030	5.8863	90.5066	82.7389	64.0760	0.2000	124.3280
0.040	6.4177	89.6423	101.2347	62.0585	0.2706	121.3023
0.050	7.3974	88.2216	119.3024	60.4163	0.2994	120.2913
0.060	8.0403	87.3883	139.6900	58.8387	0.3167	119.7311
0.070	9.5288	88.2821	157.7154	57.7141	0.3851	117.7767
0.080	11.1990	84.0747	179.8619	56.4001	0.4449	116.3322
0.090	11.1872	86.6776	203.5907	55.0718	0.5850	113.5942
0.100	11.8940	86.0649	216.9761	54.4350	0.6688	112.2560

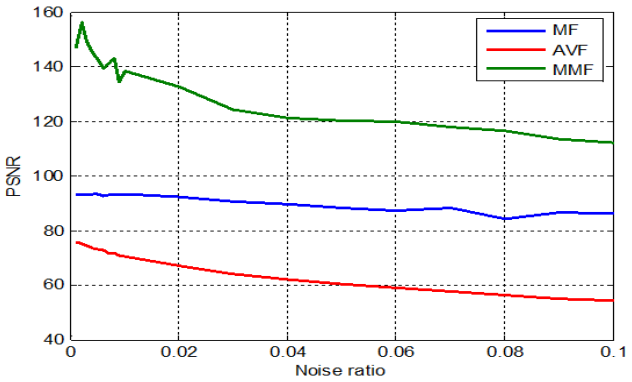

Figure-10. PSNR comparisons of AVF, MF, and MMF.

The proposed MMF was also compared with the listed methods mentioned in the related works, the lena.jpg image was taken, and various NR was applied, Figure-11 shows an example of implementing MMF applying NR=0.6

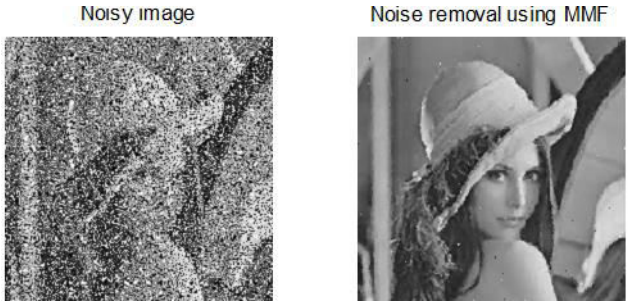

Figure-11. Applying the MMF method with NR=0.6.

Table-2 shows the experimental results comparisons using various existing methods of SAPN removal (using lensa.jpg image):

Table-2. Comparison results 2.

Noise ratio (%) 10% means NR=0.1	SM	DWM	MDWM	MDW	TVW	TSF	MMF
10	36.12	40.78	41.50	42.71	42.53	43.08	87.6720
20	33.42	37.02	38.13	39.49	39.12	39.87	78.9274
30	31.36	34.63	36.10	37.28	36.92	37.63	74.8768
40	29.88	32.51	34.16	35.41	35.16	35.79	69.8218
50	28.54	30.23	32.62	33.44	33.87	34.02	64.0610
60	26.76	27.69	31.22	31.34	32.29	32.13	54.2989
70	24.47	25.23	29.77	30.35	30.95	31.10	42.5679
80	19.52	21.00	27.94	28.81	29.12	29.45	31.8698
90	8.80	15.45	25.34	26.57	26.84	27.16	21.8231

From Table-2 we can see also that MMF method is the most effective method by providing the best values for PSNR using noise ratio less than 0.9, and this is clearly illustrated in Figure-12.

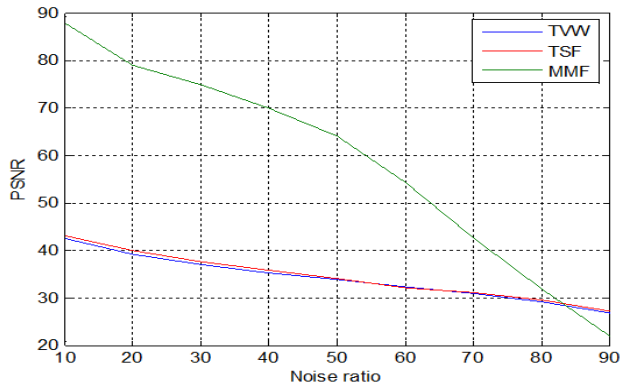

Figure-12. PSNR comparisons.

5. CONCLUSIONS

A new method of SAPN removal and reduction was proposed, this method is very effective in dealing with various noise densities. MMF was implemented and tested; the obtained experimental results showed that the proposed method is better than median and average filters by providing good value for both MSE and PSNR.

The proposed method was compared with other existing famous methods and the obtained experimental results showed that MMF is more efficient by increasing PSNR and decreasing MSE. MMF will minimize the negative effects of SAPN.

ACKNOWLEDGMENT

The researchers are grateful to the Applied Science Private University, Amman, Jordan, for the full financial support grated to this research project.

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