International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN - 2395-1990
Online ISSN : 2394-4099
Available Online at : www.ijsrset.com
doi : https://doi.org/10.32628/IJSRSET23102118

Image Enhancement using Adaptive Median Filter

Rasha Awad Abtan
Computer Department, Basic Education College, Mustansiriyah University, Baghdad, Iraq

ARTICLEINFO

Article History :

Accepted: 01 Aug 2023
Published: 10 Aug 2023

Publication Issue :
Volume 10, Issue 4
July-August-2023

Page Number :
236-243

ABSTRACT

Impulse noise frequently taints digital images as a result of errors produced by noisy sensors, faults during the analog-to-digital conversion process, and errors produced in communication channels. This persistent bug modifies the brightness of some pixels while keeping the brightness of other pixels unaltered. We looked at the Median Filter, Weighted Median Filter, and Multi-Stage Median Filter to lessen impulsive noise and enhance the quality of the impacted image. These filters enhance the image quality by removing or successfully suppressing impulse noise in the image while maintaining the information about the image's edges. In MATLAB simulations, the effectiveness of these filters was assessed on a picture that has undergone different types of impulse noise corruption (Salt-and-Pepper and Gaussian noise).
Keywords: Noise, Spatial Filtering , Statistical Digital Image .

I. INTRODUCTION

The most popular and practical method of communicating or distributing information is through images. Images effectively communicate information about situations where around 75% of the information that humans acquire is in the form of pictures [1].
Any system for processing signals must incorporate filtering, which entails estimation of a signal that has typically been weakened by impulse noise. Impulse noise is typically caused by an error that occurs when a digital signal is created from an analog signal by an analog-to-digital converter. Image enhancement techniques, which have been developed throughout the years for a range of reasons, enhance an image's quality is improve a human's ability to perceive an image. Because many satellite photos lack sufficient information to allow for picture interpretation when viewed on a color display, these techniques are very helpful. There are numerous different ways to improve the quality of a photograph. Edge enhancement, spatial filtering, contrast stretching, and density slicing are the techniques used most commonly. Following correction for geometric and radiometric aberrations, picture augmentation is attempted [1].

A different set of image enhancing methods is applied to each band in a multispectral image. Noise reduction is an important processing step that is involved in all digital image applications. Moreover, the noise level of camera sensors is still high. even with the most advanced manufacturing techniques. As a result, image de-noising is and will always be a significant research area, leading to the development of numerous filtering approaches over time for varied applications [2].

By using these filters on digital photos after adding two distinct types of noise, this paper aims to investigate and contrast three different filter types: salt-and-pepper noise and Gaussian noise, to enhance and reduce the effect of noise on the images, using the program MATLAB, R2017a.

For all kinds of photographs, the median filter is extensively used in literature.

The median filtering method described by Kesari et al. [3] maintains more edges while drastically lowering the peak signal to noise ratio (PSNR) and signal to noise ratio SNR. The technique reduces picture noise in homogeneous areas while preserving the edges in other regions. Median filtering outperforms linear filtering in decreasing noise in pictures with edges. [4]. According to Loupaset et al. [5], the adaptive weighted median filter (AWMF) is based on the ultrasound image weighted median . In order to lower the computational cost of the median filter from O(r) to O(log2(r)), Ben Weiss et al. [6] invented the idea of Fast Median and Bilateral Filtering.

Many enhancements to the median filter have been proposed.Mamtajuneja [7] proposed an impulse noise identification and removal approach based on adaptive filtering to repair pictures damaged by salt and pepper noise. An improved median filter was proposed [8] for reducing salt and pepper noise. Loupaet al [9], These have adjustable window sizes that allow impulses to be removed while still maintaining the edges' sharpness. For feature extraction, edge-preserving smoothing filters are far more appropriate.

Spatial image filters :- the new value of a pixel is dependent on both its previous value and the pixel intensities in its immediate vicinity. Each new pixel's value represents the filtering operation's results, and for each of these neighborhoods, a pixel with coordinates equal to the center of the neighborhood is created in the output image. A linear spatial filter is one that has linear filter action, and is commonly represented by a mask (also known as a window, kernel, or template) [10].

The median filter, a digital filtering technique based on non-linear ordered statistics, is widely used to significantly reduce image noise. It is one of the best windowing operators available, ranking alongside the mean, min, and max, and mode filters. The "salt-and-pepper" noise is particularly well-removed by it. The primary idea is to visually check if a sample value of an input signal accurately depicts the signal as a whole. As a result, when it comes to preserving crucial details in an image, the median filter typically outperforms the boxcar filtering technique [4]. Every pixel in the image is subjected to the median filter, and the nearest neighbors are used to assess whether or not that pixel is representative of its surroundings. The median of those values, as opposed to the mean of the adjacent pixels, is frequently used as a replacement for a pixel value by median filters. In other words, The value of the pixel in question is altered to the middle (median) pixel value after the values from the nearby region have been sorted into numerical order. The neighborhood is known as The Window. The center of a window in any shape could serve as the target pixel.

Windows made for 2D pictures frequently have a square shape. It should be noted that the median filter is frequently used with an odd-sized window. The median value that is chosen as the output, if there are even numbers of pixels in the neighborhood under consideration, is the average of the two middle pixel values. Figure 1.1 shows how to calculate the median filter in the window.

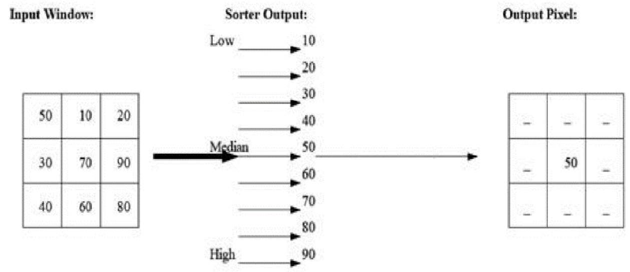

Figure 1.1: A A graphic representation of how the median filter works

A more trustworthy average than the mean value is the median value. because it is less likely to be changed noticeably by one particularly unrepresentative pixel in the surrounding area. Because of this, the median filter is superior to the mean filter and other rank order filters. A pixel in the vicinity of the window will most likely have a value equal to the median value of the pixels around. Therefore, The median filter, particularly when it operates in transition zones, has the lowest probability of generating novel, absurd pixel values. In order to maintain sharp edges, the median filtering approach works better than the mean filtering method [11].

The standard median filter has the drawback of perhaps removing noise-free portions of the image from the image. By changing (or adapting) its behavior in line with statistical characteristics of the observed picture data in the filter's region, the adaptive median filter attempts to address this problem. The method is a little more difficult, but it often produces results that are far better.

Using a weighted median filter The sole difference between it and a median filter is that the mask is not empty. It will be assigned a particular amount of weight and averaged. The steps to implement a weighted median filter are as follows [12]:

1) Assume that the mask is 3x3.
2) Set the mask in the bottom left corner.
3)Convolution is followed by multiplication. Put the nine pixels in either descending or ascending order.
4) Pick the middle value out of these nine options.
5) Position this median in the middle.
6) Drag the mask around the picture.6) Move the mask throughout the image.

Multi Stage Median Filter (MS Median Filter)

This filter is used to clean up the salt-and-pepper noise-corrupted image. Figure 2.2 demonstrates the method of determining four vectors—R1, R2, R3, and R4—from a two-dimensional window (marked by 55 W) of size 5x5 and centered on the corrected pixel p(x, y) in the damaged image. By ascending-order sorting the pixels in the selected vectors M1, M2, M3, and M4, you may determine the median pixel value. and then change the result to a new vector (M1, M2, M3, M4, M5), calculate its median, and replace the result with the center pixel of the image's 5 x 5 window with the result. Continue doing this until the entire image has been processed [6].

$$Mi = median\ (Ri)\ ;\ \ i = 1,2,3,4.$$
$$Result = median\ (M1, M2, M3, M4, M5)$$

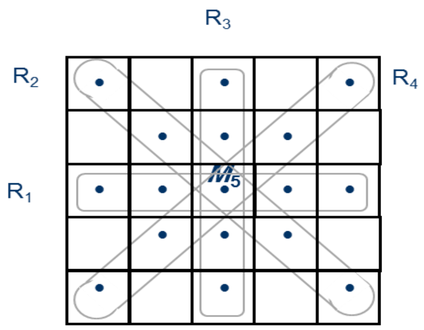

Figure1.2 : Calculate MS value for a square window of size 5x5

Types of Noise

There are other noise kinds that can be added to a digital image to distort it, but in this project, only salt-and-pepper and gaussian noise will be used [10].

Salt-and-pepper Noise

Shot noise, impulse noise, spike noise, or salt-and-pepper noise are commonly caused by faulty memory locations, problematic pixel elements in camera sensors, or issue digitization timing. In the salt-and-pepper noise, there are only two possible values, a and b, and neither has a probability greater than 0.2. The image will be obscured by noise if the numbers are higher than these numbers. In an 8-bit picture, salt and pepper noise typically has a value of 0 [10].

Gaussian Noise or Amplifier Noise

The probability density function [pdf] of this noise is modeled after the normal distribution. It also goes by the name of Gaussian distribution. The continuous level of noise in the image's dark parts makes up a significant portion of an image sensor's read noise [8].

Histogram processing

The histogram of an m × n grey-scale image is a discrete function

$$h(i) = ni \qquad \ldots\ldots(1.1)$$

Where i ∈ [0, . . . , 255] , the number of pixels in the image with intensity i, where ni is the number of grayscale pixels in the image. The definition of the normalized histogram is

$$p(i) = h(i)/mn \ \ldots\ldots(1.2)$$

and can be thought of as the likelihood that intensity i will appear in the image. This means that the probability of a randomly chosen pixel having intensity i is given by p(i), with each pixel in the image having an equal chance of being chosen. We also note that

$$p(i) > 0 \text{ for all } i = 0, \ldots, 255,$$

and $\sum_{i=0}^{255} p(i) = 1.$ ……….. (1.3)

Statistical Digital Image Properties (SNR, PSNR, RMSE)

The most important image characteristics (Single-to-Noise Ratio SNR, Peak Signal-to-Noise Ratio PSNR, and Root Mean Square Error RMSE) of the entire image or specific image sections can be found using image data.In line with [8], the discrepancy between an original and reconstructed pixel value is as follows:

$$\text{Error}(r, c) = I(r, c) - I(r, c).(1.4)$$

I(r,c): is the original image, where. I is a reconstructed image (r,c). Following that, the difference in error between the original and (decompressed) image of size (M * N) can be said the following way :

$$Totalerror = \sum_{r=0}^{M-1}\sum_{c=0}^{N-1}\left[\hat{I}(r,c) - I(r,c)\right] \qquad \ldots(1.5)$$

The Single-to-Noise Ratio (SNR):

The single-to-noise ratio is a statistic used in science and engineering to assess how strong a desired signal is in comparison to the level of background noise. A signal's or measurement's mean to standard deviation ratio [8]

$$SNR = \sqrt{\frac{\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}\left[\hat{I}(r,c)\right]^2}{\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}\left[\hat{I}(r,c) - I(r,c)\right]^2}} \qquad \ldots\ldots(1.6)$$

Peak Signal-to-Noise Ratio Measure (PSNR)

During experimental work, the PSNR measurement is utilized to assess the quality of a distorting image in comparison to its original version as an error measure. The quality approximation between the original image and the deformed image is shown by the computed PSNR value. Prior to deriving the PSNR, the MSE should be computed. Here, "O" and "D" stand for the binary values of the original and warped picture pixels, which are to be compared, respectively. The size of the image is "m× n" [9].

$$PSNR = 10\log_{10}\frac{(L-1)^2}{\frac{1}{N*M}\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}\left[\hat{I}(r,c) - I(r,c)\right]^2} \qquad \ldots\ldots(1.7)$$

Root Mean Square Error (RMSE)

Mean square error is given by

$$MSE = \sum_{i=j=1}^{N}\left[f(i,j) - F(i,j)\right]^2 / N^2. \qquad \ldots\ldots(1.8)$$

f is the original image where F is the image after it has been denoised by a filter, and N is its size [10].

$$RMSE = \sqrt{MSE} \qquad \ldots\ldots(1.9)$$

II. PRACTICAL PART

The increasing production of digital photos and movies of all kinds, frequently shot in subpar lighting circumstances, has increased the demand for effective image restoration techniques. No matter how good a camera is, a better image is always preferred to increase its scope of use. Noise is the main factor limiting the accuracy of images.A noisy image is entered into an image denoising process, which produces a reduced-noise image. In this study, Gaussian and Salt & Pepper noise were added to the original image, and the extra noise was then removed using the median filter, weighted median filter, and MS median filter, three different types of filters. To compare the generated images, the Single-to-Noise Ratio SNR, Peak Signal-to-Noise Ratio PSNR, and Root Mean Square Error RMSE criteria were utilized. The default image, Lena, is silently loaded when the user starts the app. The user is then prompted by a popup input box to select the type of noise they want to apply to the input image: 1 for Gaussian noise and 2 for Salt & Pepper noise. Beginning with selection 1, let's choose Salt & Pepper noise, as seen in figure 1.3.

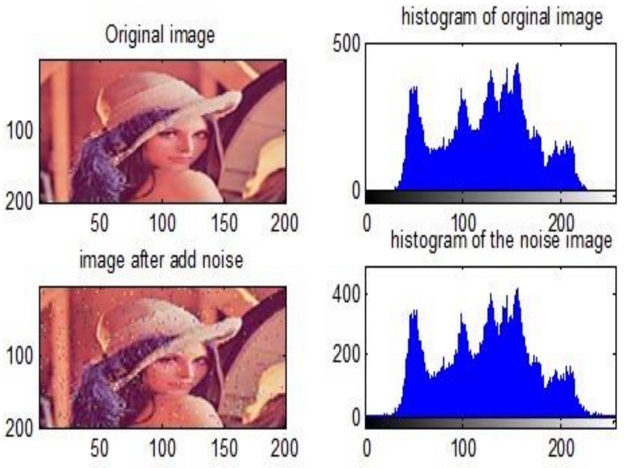

Figure 1.3: the two original image and the image after added Salt & Pepper noise with their histograms.

Figure 1.3 shows the original image and histogram in the first row and the image with noise added in the second row.The noise will be eliminated from the image using a median filter. The denoising image and associated histogram are displayed in the third row of Figure 1.4.

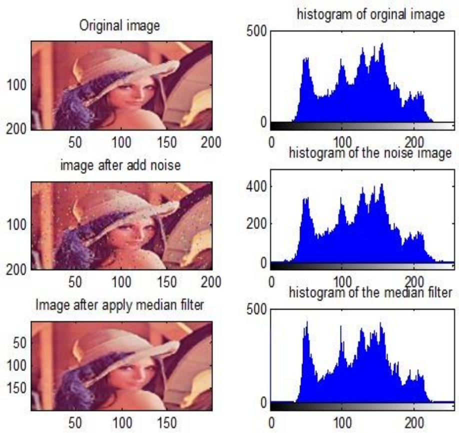

Figure 1.4 the denoising image with its histogram

The figure 1.5 show denoising image by weighted Median Filter and its histogram in third row after select second choice.

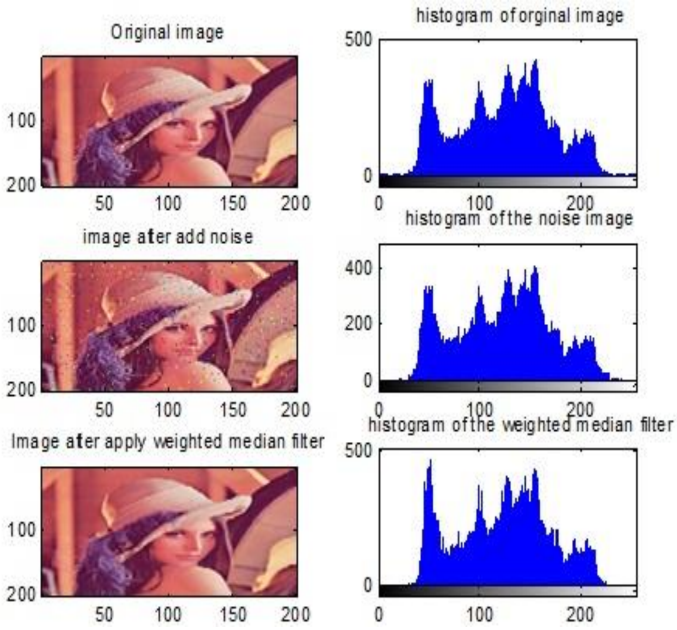

Figure 1.5 denoising image by weighted Median Filter and its histogram

The Figure 1.6: The denoising image by MS Median Filter and its histogram in third row after select third choice.

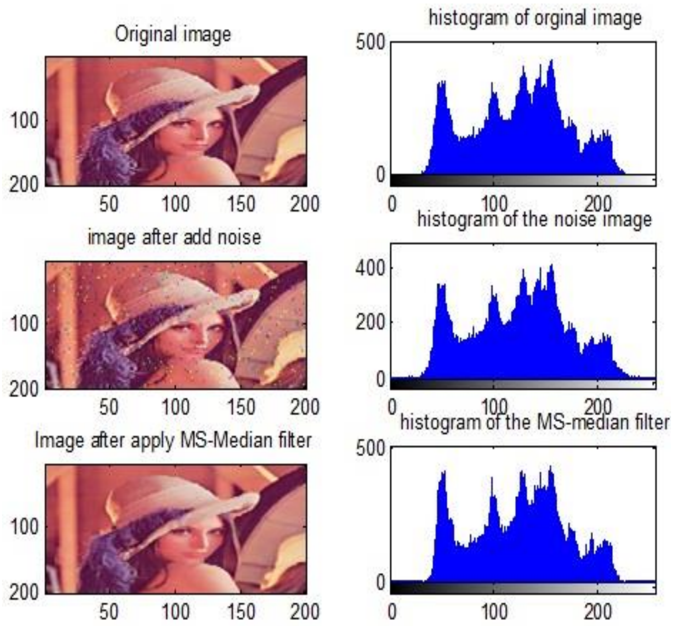

Figure 1.6: The denoising image by MS Median Filter and its histogram

When the program restarts, which in this case entails the addition of Gaussian noise to the original image . Figure 1.7 illustrates the same procedure with Gaussian noise added to the original image.

Figure 1.7: the two original image and the image after added Gaussian Noise with their histograms.

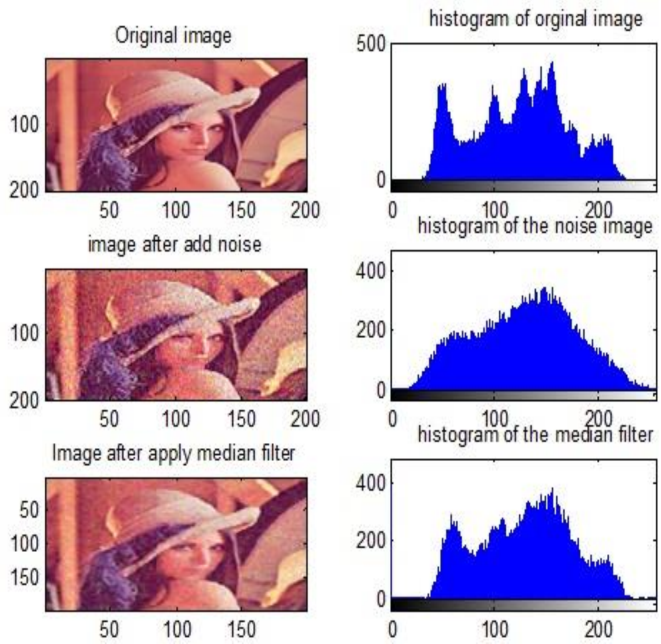

Figure 1.8: The denoising image by Median Filter and its histogram in third row after select first choice.

The denoising image by weighted Median Filter and its histogram in third row after select second choice show in figure 1.9.

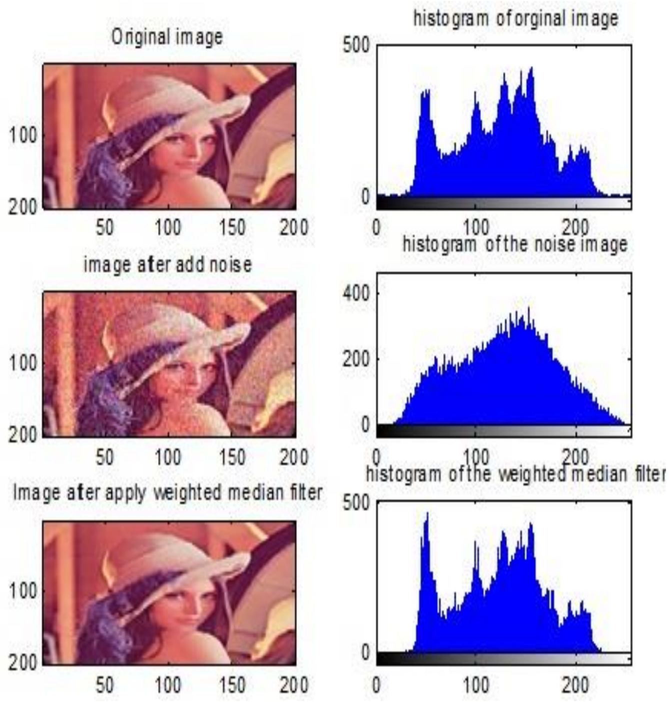

Figure 1.9: The denoising image by weighted Median

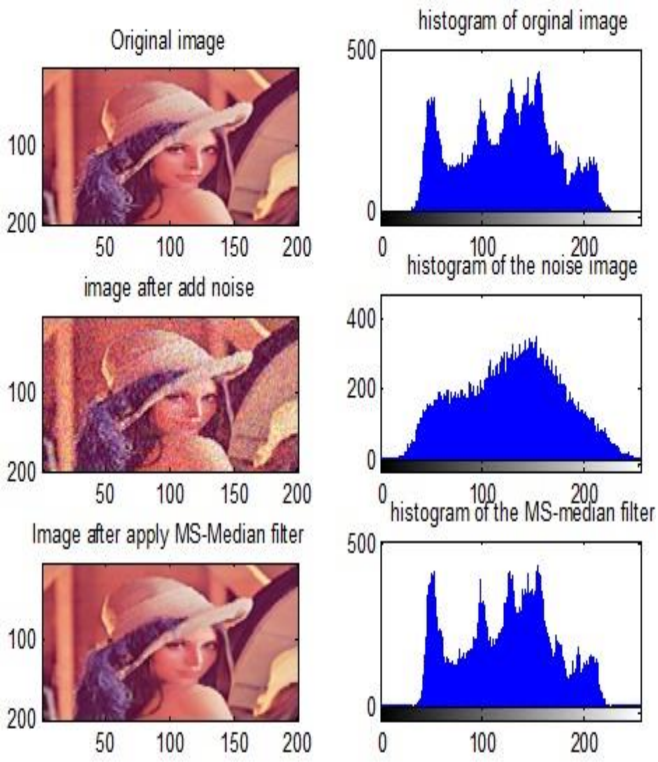

Figure 1.10 : The denoising image by MS Median Filter and its histogram in third row after select third choice.

The quality of the resulting images was calculated after the filtering process and compared with the original images and the noised images using the modified statistical: Single - to- Noise Ratio, Peak Signal-to-

Noise Ratio , and Root Mean Square Error . The noised image after the addition of the noise type (Salt & Pepper) , and finally the filtered images using the three filters used in this paper Median Filter, weighted Median Filter, and MS Median Filter . In this study, four images were utilized to demonstrate how adding and eliminating noise affected each image individually. Lena, A1 (vegetables), A2 (gorilla), and A3 (airships) are the images that were used, as seen in figure 1.11.

Figure 1.11: The used images in this study

Table 1.1: the result of calculated criteria of all images: original image, noised image with Salt & Pepper Noise, denoizing images.

Lena	Gausian		
	PSNR	SNR	RMSE
Median	34.8523	6.9318	16.2532
WM	33.26	6.7716	16.6647
MSM	44.7208	24.5767	4.454
A1/ Vegetables	Gausian		
	PSNR	SNR	RMSE
Median	28.9313	9.7069	27.4304
WM	28.4406	6.7716	29.0246
MSM	42.9684	47.2176	5.4497
A2/ Gorilla	Gausian		
	PSNR	SNR	RMSE
Median	25.0435	6.5930	42.9163
WM	25.0874	6.638	42.6998
MSM	29.3098	10.3959	26.2605
A3/ Airships	Gausian		
	PSNR	SNR	RMSE
Median	30.6434	8.1784	22.5229
WM	30.5229	8.0647	22.8377
MSM	44.4838	40.0122	4.5773

The procedure was repeated, and the criteria were determined; however, in this instance, the results are shown in table 1.2 after the addition of Gaussian noise.

Table 1.2: the result of calculated criteria of all images: original image, noised image with Gaussian Noise, denoizing images.

Lena	S&P		
	PSNR	SNR	RMSE
Median	34.8523	7.8527	13.8733
WM	34.8936	7.8937	13.8075
MSM	44.7208	24.5767	4.454
A1/ Vegetables	S&P		
	PSNR	SNR	RMSE
Median	33.382	15.6407	16.4322
WM	33.4198	15.7151	16.3609
MSM	42.9684	47.2176	5.4497
A2/ Gorilla	S&P		
	PSNR	SNR	RMSE
Median	26.3967	7.4392	36.7249
WM	26.8587	7.8578	34.8225
MSM	29.3098	10.3959	26.2605
A3/ Airships	S&P		
	PSNR	SNR	RMSE
Median	31.5531	8.9763	20.2833
WM	31.5753	9.0028	20.2316
MSM	44.4838	40.0122	4.5773

The final results have been obtained indicate that adding the noise to the original image reduces the quality of the image. Tables 1.1 and 1.2 show that noise of the type Gaussian have more effect and distortion on the original image than the noise of type Salt & Pepper. On the other hand, using Median Filter and MS Median Filter to remove the noise type Salt & Pepper and Gaussian gives the best result using weighted Median Filter, and this is very clear through the images have been obtained and the calculation of the criteria in the tables above.

III. CONCLUSION

The following findings were drawn from the methods of picture denoising in this work employing Median, Wieghted-Median, and Multi-Stage Median filters:

1. Applying the Median filter technique to color images that have been distorted by Salt&Pepper noise produces better results than when Gaussian noise is used.
2. weighted median filter in spatial domain give the best results based on objective criteria with less blur in image denoising than the median.
3. Applying multi-stage median filters in the spatial domain produces results that are superior to median filters in terms of objective criteria and reduce blur in picture denoising.

IV. REFERENCES

[1]. Sh Radhi. Al Taweel "Study of TV- Satellite Images and Analysis of their Associated Noise in Digital Receiver System" Ph.D thesis, College of Education, Al-Mustansiriya University,(2006).

[2]. H. Abdullah. Al-Jubouri, "Study of the noise accompanying the images of terrestrial television broadcasting and ways to reduce its impact", PhD thesis Department of Physics, University of Mustansiriya college of Science, (2006)

[3]. V Kesari , B K Singhb , A.S. Thoke ," An Enhancement in Adaptive Median filter for Edge Preservation" , Department of Computer Applications, National Institute of Technology Raipur Chhattisgarh , v 48 (2015) , doi: 10.1016/j.procs.2015.04.106.

[4]. E A Castro , D L. Donoho, " Does Median Filtering Truly Preserve Edges Better than Linear Filtering".The Annals of Statistics 2009, Vol. 37, No. 3, 11721206 DOI: 10.1214/08-AOS604.

[5]. T. Loupas,, W. N. Mcdicken,. "An Adaptive Weighted Median Filter for Speckle Suppression in Medical Ultrasonic Images". .IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS, VOL. 36, NO. 1, JANUARY 1989.

[6]. B Weiss. F M edian ., " ilateral F iltering". 2006 ACM 0730-0301/06/0700-0519.

[7]. M Juneja ., R Mohana. "An Improved Adaptive Median filtering Method for Impulse Noise Detecion" , .International Journal of Recent Trends in Engineering, Vol 1, No. 1, May 2009.

[8]. S Singh. , N R Prakash., " Modified Adaptive Median for Salt & Pepper noise" . International Journal of Advanced Researh in Computer and Communication Engineering.

[9]. S. Esakkirajan, T. Veerakumar, Adabala N. Subramanyam, and C. H. PremChand., " Removal of High Density Salt and Pepper NoiseThrough Modified Decision Based UnsymmetricTrimmed Median Filter". IEEE SIGNAL PROCESSING LETTERS, VOL. 18, NO. 5, MAY 2011

[10]. S.K Huda, AL-Ghrabi " Quantum analysis of Noise in photonic system " , M.Sc .thesis , physics Dept ,College of education for women , Baghdad University , (2001).

[11]. J .M, Eliham " Digital filter for speckle noise reduction " ,M.Sc . thesis , physics Dept .,college of science AL –Mustansiriya university .,(2003).

[12]. D Hazem.. Al-Khuzaie, "Removing Collective Noise from Color Images Using the Smallest Curves Approach to approxmating Curves", Master Thesis, Baghdad University / Faculty of Education / Ibn al-Haytham, (2004).

Cite this article as :

Rasha Awad Abtan, "Image Enhancement using Adaptive Median Filter", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 10 Issue 4, pp. 236-243, July-August 2023. Available at doi : https://doi.org/10.32628/IJSRSET23102118
Journal URL : https://ijsrset.com/IJSRSET23102118