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To remove high density salt and pepper noise and compare output images with image quality metrics by advanced median filter

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Abstract—In this paper, a technique is used that removes high density salt and pepper noise from corrupted image and compares the output images with the original image by image quality metrics. Instead of replacing the pixel value with the mean of neighboring pixel values, the method replaces it with the median of those values. This technique compares between corrupted and uncorrupted pixels and performs the median filtering process only on the corrupted ones. A 3*3, 5*5 and 7*7 square neighborhood is used here. We will observe the output images with lower neighborhoods and higher neighborhoods. We will also show the calculation of PSNR (Peak Signal to Noise Ratio) and MSE (Mean square error) value for each dimension with different percentages.

Index Terms—Median filter ,MSE,PSNR,Image Quality Metrices

1 Introduction

AN image is nothing more than a two dimensional signal. It is defined by the mathematical function f (x, y) where x and y are the two co-ordinates horizontally and vertically.The value of f (x, y) at any point is gives the pixel value at that point of an image. [1] Noise is an unwanted signal which interferes with the original message signal and corrupts the parameters of the message signal.[2] This alteration in the communication process, leads to the message getting altered. It is most likely to be entered at the channel or the receiver.Image noise is random (not present in the object imaged) variation of brightness or color information in images, and is usually an aspect of electronic noise. It can be produced by the sensor and circuitry of a scanner or digital camera[2]. Digital images are prone to various types of noise[3]. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene [2]. There are several ways that noise can be introduced into an image, depending on how the image is created.If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise can also be the result of damage to the film, or be introduced by the scanner itself. If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise.Electronic transmission of image data can introduce noise. iii The Salt and Pepper type noise is typically caused by malfunctioning of the pixel elements in the camera sensors, faulty memory locations, or timing errors in the digitization process. For the images corrupted by Salt and Pepper noise, the noisy pixels can take only the maximum and the minimum values in the dynamic range. The term impulse noise is also used for this type of noise [4] . Other terms are spike noise, random noise or independent noise. Dust particles in the image acquisition source or over heated faulty components can cause this type of noise. Image is corrupted to a small extent due to noise. With the development of the medical imaging and the imaging equipment, [5] although medical image quality has been improved significantly, and the noise in the majority of images can not be identified artificially, the projection data in the actual scanning process is still interfered inevitably by various noise, and the traditional denoising method can't possess both of reducing image noise and retaining image details. Salt and pepper noise also creates difficulties on other imaging system . The Arithmetic Mean Filtering Technique can remove Salt and Pepper noise from the distorted image but in this case the filtered image suffers the blurring effect. For the median filtering techniques each pixel is considered to calculate the median and also every pixel is replaced by that calculated median . So affected pixels are considered to calculate the median and unaffected pixels are also replaced by this calculated median. Researchers have been studied a lot to remove salt and pepper noise espeacilly at high densities. In our present research work we will remove noise using median filter from an image which is corrupted by impulse noise (salt and pepper noise) at different percentage and compare those output images with image quality metrics.

2 Theory

2.1 Median Filter

The median filter considers each pixel in the image in turn and looks at its nearby neighbors[1]. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. (If the neighborhood under consideration contains an even number of pixels, the average of the two middle pixel values is used) . Figure illustrates an example calculation

121	125	126	130	140
122	**121**	**126**	**127**	135
118	**120**	**160**	**125**	134
119	**116**	**119**	**123**	133
111	116	110	120	130

Sorted values – 116, 119, 120, 121, 123, 125, 126, 127, 160 So, 160 will be replaced by 123 Figure: Calculating the median value of a pixel neighborhood. As can be seen, the central pixel value of 160 is rather unrepresentative of the surrounding pixels and is replaced with the median value: 123. A 3×3 square neighborhood is used here.

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2.2 Image Quality Metrices

Image quality can degrade due to distortions during image acquisition and processing [14]. Examples of distortion include noise, blurring, ringing, and compression artifacts.Efforts have been made to create objective measures of quality. For many applications, a valuable quality metric correlates well with the subjective perception of quality by a human observer. Quality metrics can also track unperceived errors as they propagate through an image processing pipeline, and can be used to compare image processing algorithms. If an image without distortion is available, you can use it as a reference to measure the quality of other images. For example, when evaluating the quality of compressed images, an uncompressed version of the image provides a useful reference. In these cases, you can use full-reference quality metrics to directly compare the target image and the reference image. Full-Reference Quality Metrics Full-reference algorithms compare the input image against a pristine reference image with no distortion. These algorithms include:

MSE— Median-squared error (MSE). MSE measures the average squared difference between actual and ideal pixel values. This metric is simple to calculate but might not align well with the human perception of quality.

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

PSNR — Peak signal-to-noise ratio (PSNR). PSNR is derived from the median square error, and indicates the ratio of the maximum pixel intensity to the power of the distortion. Like MSE, the PSNR metric is simple to calculate but might not align well with perceived quality.

PSNR=10*log10(255*255/MSE)

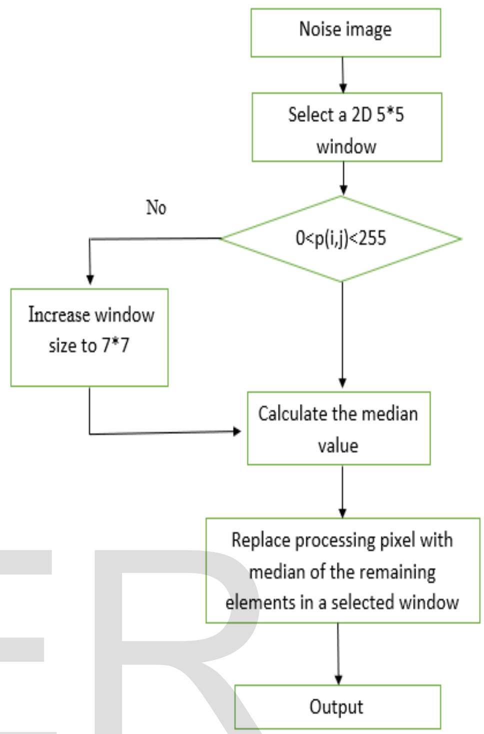
3 Sections

The Advanced Median Filter classifies pixels as noise by comparing each pixel in the image to its surrounding neighbor pixels. The size of the neighborhood is adjustable, as well as the threshold for the comparison. A pixel that is different from a majority of its neighbors, as well as being not structurally aligned with those pixels to which it is similar, is labeled as impulse noise. These noise pixels are then replaced by the median pixel value of the pixels in the neighborhood that have passed the noise labeling test. Advanced median filter changes size of Sxy (the size of the neighborhood) during operation

3.1 Proposed algorithm:

Level A: A1 = Zmed - Zmin
A2 = Zmed – Zmax
if A1 > 0 AND A2 < 0, go to level B
else increase the window size
if window size < Smax, repeat level A
else output Zxy
Level B: B1 = Zxy - Zmin
B2 = Zxy - Zmax
if B1 > 0 AND B2 < 0, output Zxy
else output Zmed
Where
Zmin = minimum gray level value in Sxy
Zmax = maximum gray level value in Sxy
Zmed = median of gray levels in Sxy
Zxy = gray level at coordinates (x, y)
Smax = maximum allowed size of Sxy

3.2 Flow Chart:



4 Results and Discussion:

Input image: I have chosen the input image for this project is Lenna.jpg is given below. Advanced Median Filter is applied on this image.

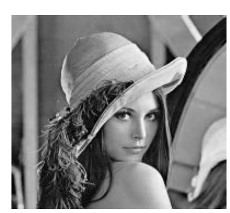


Fig. 1. Original image

Output images: Output images for 3*3 , 5*5 and 7*7 window is shown here.
We get different PSNR and MSE values for different dimensions. 3*3 window:

The output images are shown for 3*3 window. Figure (a) shows for noise density 10 % (b) shows for noise density 20 % (c) shows for noise density 30 % (d) shows for noise density 40 % (e) shows for noise density 50 % (f) shows for noise density 60 % (g) shows for noise density 70 % (h) shows for noise

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density 80 %.

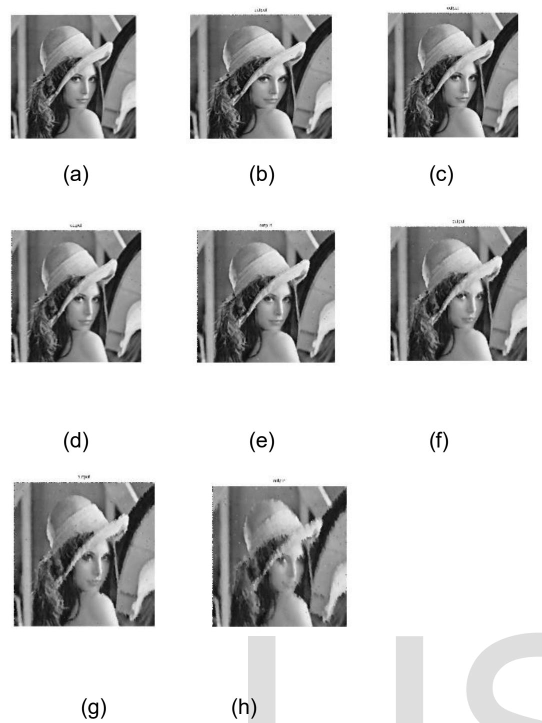
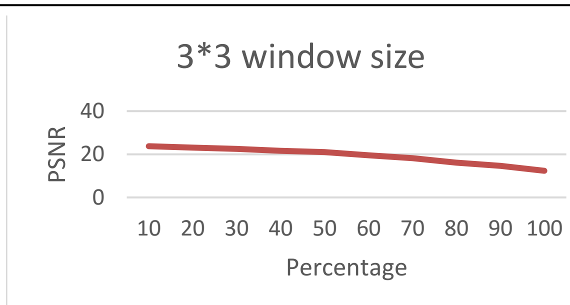
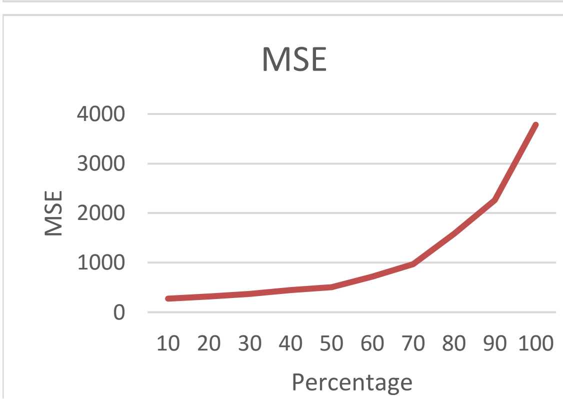


Fig. 2. For 3*3 window output images with different noise density (a) 10% (b) 20% (c) 30% (d) 40% (e) 50% (f) 60% (g) 70% (h) 80%.

Graph of PSNR and MSE for 3*3 window size:





When the noise density is 10%, then the output image is clear than the output image of noise density 20%. In the figures it is seen that the output image is getting blur respectively. Because the density of noise is getting higher. The more noise is added in an image, the worse the performance. We get different MSE and PSNR values for different noise density in an image. The MSE and PSNR is calculated by comparing the output images with input image. The calculation of MSE and PSNR values for 3*3 window are given in the following table 1.

Percentage	MSE	PSNR
10	80.16	29.09
20	102.06	28.04
30	129.61	27.004
40	161.95	26.03
50	216.00	24.78
60	302.87	23.03
70	426.80	21.82
80	771.94	19.52
90	1623.86	16.02
100	7455.88	9.40

Table 1 - MSE and PSNR value for 3*3 window with different percentage.

For **3*3 window**, the MSE and PSNR value is quite good but the image contains some noise too. When noise density is 10 %, the MSE value is 80.16 and PSNR value is 29.09. At 20% of noise density, the MSE value is getting high and PSNR value is getting low. Because the more the noise density, the worse the performance. When noise density is 30%, the MSE value is 129.61 and PSNR value is 27.004. At 40% of noise density, the MSE value is 161.95 and PSNR value is 26.03. When noise density is 100%, the MSE value is 7455.88 and PSNR value is 9.40. At 100% of noise density, the performance is worst.

5*5 window: The output images are shown for 5*5 window. Figure (a) shows for noise density 10 % (b) shows for noise density 20 % (c) shows for noise density 30 % (d) shows for noise density 40 % (e) shows for noise density 50 % (f) shows for noise density 60 % (g) shows for noise density 70 % (h) shows for noise density 80 %.

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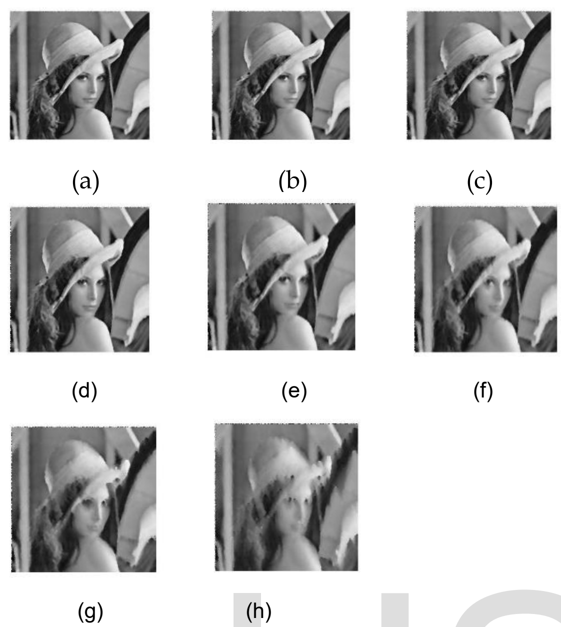

Fig. 3. For 5*5 window output images with different noise density (a) 10% (b) 20% (c) 30% (d) 40% (e) 50% (f) 60% (g) 70% (h) 80%.

When the noise density is 10%, then the output image is clear than the output image of noise density 20%. In the figures it is seen that the output image is getting blur respectively. Because the density of noise is getting higher. But the output images are getting blur than 3*3 dimension after increasing the noise density.We get different MSE and PSNR values for different noise density in an image. The MSE and PSNR is calculated by comparing the output images with input image. The calculation of MSE and PSNR values for 5*5 window are given in the following table 2.

Percentage	MSE	PSNR
10	174.33	25.71
20	207.96	24.95
30	247.08	24.20
40	292.09	23.47
50	378.48	22.35
60	512.06	21.03
70	794.16	19.13
80	1261.02	17.12
90	2168.00	14.77
100	4395.94	11.70

Graph of PSNR and MSE for 5*5 window size:

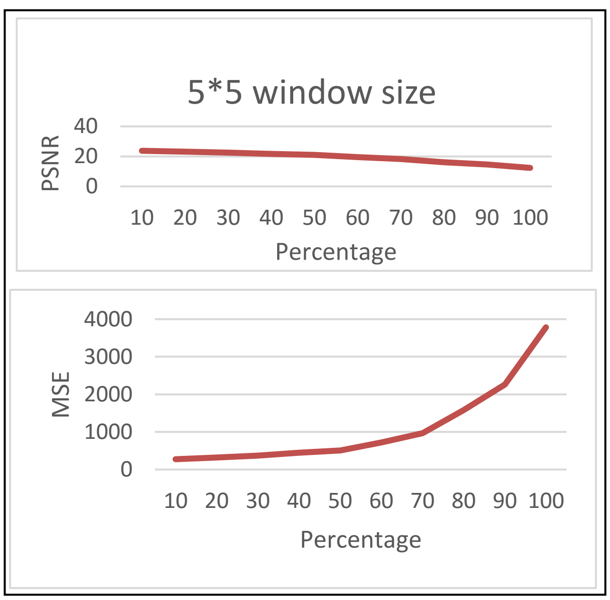

Table 2 - MSE and PSNR value for 5*5 window with different percentage.When noise density is 10 %, the MSE value is 174.33 and PSNR value is 25.71. At 20% of noise density, the MSE value is getting high and PSNR value is getting low. Because the more the noise density, the worse the performance. When noise density is 30%, the MSE value is 247.08 and PSNR value is 24.20. At 40% of noise density, the MSE value is 292.09 and PSNR value is 23.47. When noise density is 100%, the MSE value is 4395.94 and PSNR value is 11.70. At 100% of noise density, the performance is worst.

7*7 window: The output images are shown for 7*7 window. Figure (a) shows for noise density 10 % (b) shows for noise density 20 % (c) shows for noise density 30 % (d) shows for noise density 40 % (e) shows for noise density 50 % (f) shows for noise density 60 % (g) shows for noise density 70 % (h) shows for noise density 80 %.

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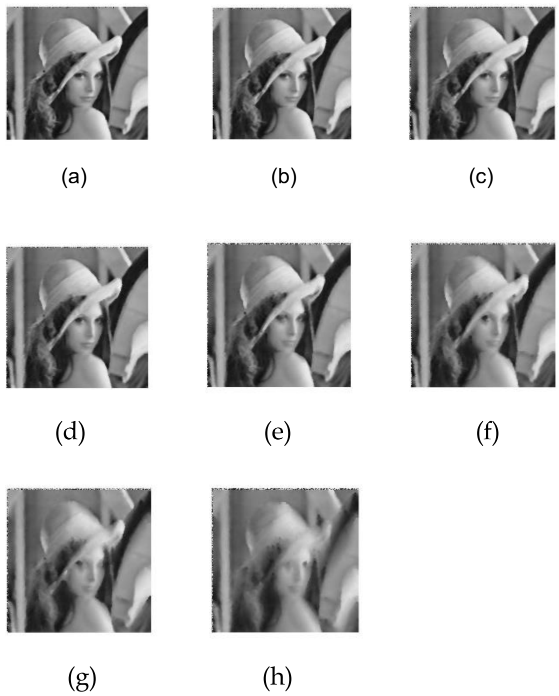
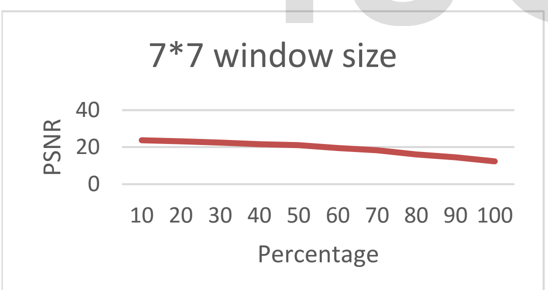
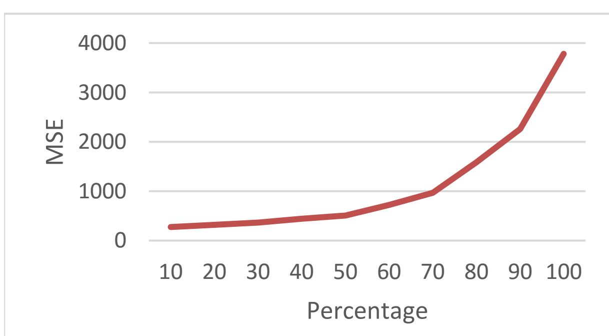


Fig. 4. For 7*7 window output images with different noise density (a) 10% (b) 20% (c) 30% (d) 40% (e) 50% (f) 60% (g) 70% (h)

Graph of PSNR and MSE for 7*7 window size:





When the noise density is 10%, then the output image is clear than the output image of noise density 20%. At 80% of noise density the output image is worst. Because the density of noise is getting high. The output images are more blur than 3*3 dimension and 5*5 dimensions output after increasing the noise density. We get different MSE and PSNR values for different noise density in an image. The MSE and PSNR is calculated by comparing the output images with input image. The calculation of MSE and PSNR values for 7*7 window are given in the following table 3

Percentage	MSE	PSNR
10	274.42	23.74
20	317.64	23.11
30	366.94	22.48
40	444.79	21.64
50	508.16	21.07
60	720.25	19.55
70	971.01	18.25
80	1584.06	16.13
90	2262.95	14.58
100	3783.31	12.35

Table 3 - MSE and PSNR value for 7*7 window with different percentage.

For 7*7 window, the MSE and PSNR value is quite low but the image contains less noise than 3*3 and 5*5 window using images. When noise density is 10 %, the MSE value is 274.42 and PSNR value is 23.74. When noise density is 20%, the MSE value is 317.64 and PSNR value is 23.11. At 30% of noise density, the MSE value is also getting high and PSNR value is also getting low. Because the more the noise density, the worse the performance. At 40% of noise density, the MSE value is 444.79 and PSNR value is 21.64. At 50% of noise density, the MSE value is 508.16 and PSNR value is 21.07. When noise density is 100%, the MSE value is 3783.31 and PSNR value is 12.35. At 100% of noise density, the performance is worst.

Conclusion

In this paper we have developed a technique that shows larger neighborhoods will produce more severe smoothing than lower neighborhoods. If I use 3*3 window in this technique then I get less MSE values and good PSNR values but it removes less noise than larger window. Larger window produces poor PSNR values and higher MSE values but it removes noise more than lower windows. The main disadvantage of this technique is it produces a blur image if noise density of an image is high. The performance of this technique is better than mean filtering techniques. So, larger neighborhoods will produce more severe smoothing than lower neighborhoods. In future I will try to explore the effect of other filtering techniques over noisy image and upgrade them according to achieve the better performance. I will try to work with the higher density noise so that it doesn't blur the output images in higher density.

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