Performance Analysis of Spatial and Adaptive Median Filters for noise removal Of Digital Images.

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***Abstract:*An image is often corrupted by noise in its acquisition or transmission. Nose is any undesired information that contaminates an image. Noise appears in images from variety of sources. The purpose of denoising is to remove the noise while retaining as much as possible the important signal features. De noising can be done through Filtering techniques. In this Paper the performance of Average and Median filters is analyzed based on their ability to remove noise. Here Impulse noise is added to both gray scale and color images And then both Averaging and Median Filtering techniques are applied to the noisy images using MATLAB. The experimental results are shown which indicate the better filtering technique for the purpose of salt and pepper noise removal in the digital images.**

***IndexTerms*-Denoising, Impulse noise, Spatial filters, Adaptive median filters, MATLAB**

I. INTRODUCTION

Image noise removal plays a vital role in image processing as a pre-processing stage. Noise represents unwanted information which deteriorates image quality. Noise is a random variation of image intensity and visible as grains in the image. Noise will introduce pixels within the picture and presents different intensity values rather than correct pixel values. Noise originates from the physical nature of detection processes and has many specific forms and causes, Noise is defined as a process (n) which affects the acquired image (f) and is not part of the scene (initial signals), and so the noise model can be written as : f(i , j) = s(i , j) + n(i , j).

In digital images, noise may come from various sources. The acquisition process for digital images converts optical signals into electrical signals and then into digital signals and is one process by which the noise is introduced in digital images. Each step in the conversion process experiences fluctuations, caused by natural phenomena, and each of these steps adds a random value to the resulting intensity of a given pixel.

The non-ideal imaging systems introduce potential degradations in digital images. Noise disturbances may also be caused by electronic imaging sensors, film granularity, and channel noise. High levels of noise are always undesirable; hence noise removal has to be employed before the image could be used for further analysis.

II. CHARACTERISTICS OF NOISE

Noise in digital images arises during

i)Acquisition: Environmental conditions(light level &sensor temperature and type of cameras

ii)Transmission: Interference in the transmission channel. To remove noise we need to understand the spatial andfrequency characteristics(Fourier Transform) of noise.

Generally spatial noise is assumed to be independent of position in an image and uncorrelated to the image itself. Frequency properties refer to the frequency content of noise in the Fourier sense.

III. TYPES OF NOISE

During image acquisition or transmission, several factors are responsible for introducing noise in the image. Depending on the types of disturbance, the noise can affect the image to different extent. Our main concern is to remove certain kind of noise. So we have to first identify certain type of noise and apply different algorithms to remove the noise. The common types of noise are:

i) Salt Pepper Noise: Salt and pepper noise is an impulse type of noise. This type of noise is coming due to errors in data transmission. This noise occurs in the image because of sharp and sudden changes of image signal. For images corrupted by salt and pepper noise the noisy pixels can take only the maximum and the minimum values in the dynamic range. It is found that an 8- bit image, the typical value for pepper noise is 0 and for salt noise it is 255. The salt and pepper noise is generally caused by malfunctioning of pixel elements in the camera sensors, faulty memory locations or timing errors in the digitization process.

ii) **Gaussian noise**: Gaussian noise is evenly distributed over signal. This means that each pixel in the noisy image is the sum of the true pixel value and a random Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point. A special case is white Gaussian noise, in which the values at any pair of times are identically distributed and statistically independent. White noise draws its name from white light. Principal sources of Gaussian noise in digital images arise during acquisition, for example sensor noise caused by poor illumination or high temperature or transmission.

iii) **Speckle noise**:

Speckle noise is multiplicative noise unlike the Gaussian and salt pepper noise. This noise can be modelled by random vale multiplications with pixel values of the image and can be expressed as

P = I + n * I where P is the speckle noise distribution image, I is the input image and n is the uniform noise image by mean and variance v. Speckle noise is commonlyobserved in radar sensing system, although it may appear in any type of remotely sensed image utilizing coherent radiation. Like the light from a laser, the waves emitted by active sensors travel in phase and interact minimally on their way to the target area. Reducing the effect of speckle noise permits both better discrimination of scene targets and easier automatic image segmentation.

IV. NOISE REMOVAL TECHNIQUES:

Image de-noising is very important task in image processing for the analysis of images. One goal in image restoration is to remove the noise from the image in such a way that the original image is discernible. In modern digital image processing data de-noising is a well- known problem and it is the concern of diverse application areas. Image de-noising is often used in the field of photography or publishing where image was somehow degraded but needs to be improved before it can be printed. When we have a model for the degradation process, the inverse process can be applied to the image to restore it back to the original form. There are two types of noise removal approaches (i) linear filtering (ii) nonlinear filtering.

Linear Filtering: Linear filters are used to remove certain types of noise. These filters remove noise by convolving the original image with a mask that represents a low-pass filter or smoothing operation. The output of a linear operation due to the sum of two inputs is the same as performing the operation on the inputs individually and then summing the results. These filters also tend to blur the sharp edges, destroy the lines and other fine details of the image. Linear methods are fast but they do not preserve the details of the image.

Non-Linear Filtering: Non- linear filter is a filter whose output is not a linear function of its inputs. Non-linear filters preserve the details of the image. Non-linear filters have many applications, especially removal of certain types of noise that are not additive. Non-linear filters are considerably harder to use and design than linear ones.

V. IMAGE DENOISING

The goal of de noising is to remove the noise while retaining as much as possible the important image features. De noising can be done through filtering, The main filters in those categories are
i)Average Filter/Mean Filter
ii)Median Filter
iii) Adaptive Median Filter

5.1Mean Filter

Average filtering is a simple, intuitive and easy to implement method of smoothing images, i.e. reducing the amount of intensity variation between one pixel and the next. It is often used to reduce noise in images. The idea of mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbours, including itself. Thishas the effect of eliminating pixel values which are unrepresentative of their surroundings. Mean filtering is usually thought of as a convolution filter. Like other convolutions it is based around a kernel, which represents the shape and size of the neighbourhood to be sampled when calculating the mean. Often a 3×3 square kernel is used, as shown in Figure 1, although larger kernels (e.g. 5×5 squares) can be used for more severe smoothing.

8	4	7
2	1	9
5	3	6

Table 5.1:Mean Filter
This provides a calculated value of 5. The center value is 1, in the pixel matrix and it is replaced with this calculated value 5.

5.2 Median Filter

Median filter is a simple and powerful non-linear filter which is based on order statics, whose response is based on the ranking of pixel values contained in the filter region. It is easy to implement method of smoothing images. Themedian filter also follows the moving window principle similar to the mean filter. A 3*3, 5*5, or 7*7 kernel of the pixels is scanned over pixel matrix of the entire image. In this filter, we do not replace the pixel value of the image with the mean of all neighboring pixel values; we replace it with the median value. Median filtering is done by, first sorting all the pixel valuesfrom the surrounds neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value**.**

124	125	127	131	141
123	125	127	128	136

119	121	154	126	135
120	116	120	124	134

Table 5.2:Median Filter

[Here neighbourhood values are 116 120 121 124 125 126 127 128 154 and median value= 125].

5.3 Adaptive Median Filter

The Adaptive Median Filter performs spatial processing to determine which pixels in an image have been affected by impulse noise. The Adaptive Median Filter classifies pixels as noise by comparing each pixel in the image to its surrounding neighbour pixels. The size of the neighbourhood is adjustable, as well as the threshold for the comparison. A pixel that is different from a majority of its neighbours, as well as being not structurally aligned with those pixels to which it is similar, is labelled as impulse noise. Adaptive filter works based on the following algorithm.

Z_{min} = Minimum gray level value in S_{xy}.

Z_{max} = Maximum gray level value in S_{xy}

Z_{med} = Median of gray levels in S_{xy}

Z_{xy} = gray level at coordinates (x, y)

S_{max} = Maximum allowed size of S_{xy}

The adaptive median filter works in two levels denoted Level A and Level B as follows:

Level A:

$A1 = Z_{med} - Z_{min}$
$A2 = Z_{med} - Z_{max}$

If A1 > 0 AND A2 < 0, Go to level B
Else increase the window size

If window size <= S_{max} repeat level A
Else output Z_{xy}.

Level B:

$B1 = Z_{xy} - Z_{min}$
$B2 = Z_{xy} - Z_{min}$
If B1 > 0 And B2 < 0 output Z_{xy}
Else output Z_{med}.

These noisy pixels are then replaced by the median value of the pixels in the neighbourhood that have passed the noise labelling test. Adaptive median filter changes the size of the neighbourhood (window) during operation. The standard median filter does not perform well when the noise density is high, while the adaptive median filter can better handle these noises. Also, the adaptive median filter preserves image details such as edges and smooth nonimpulsive noise, while the standard median filter does not.

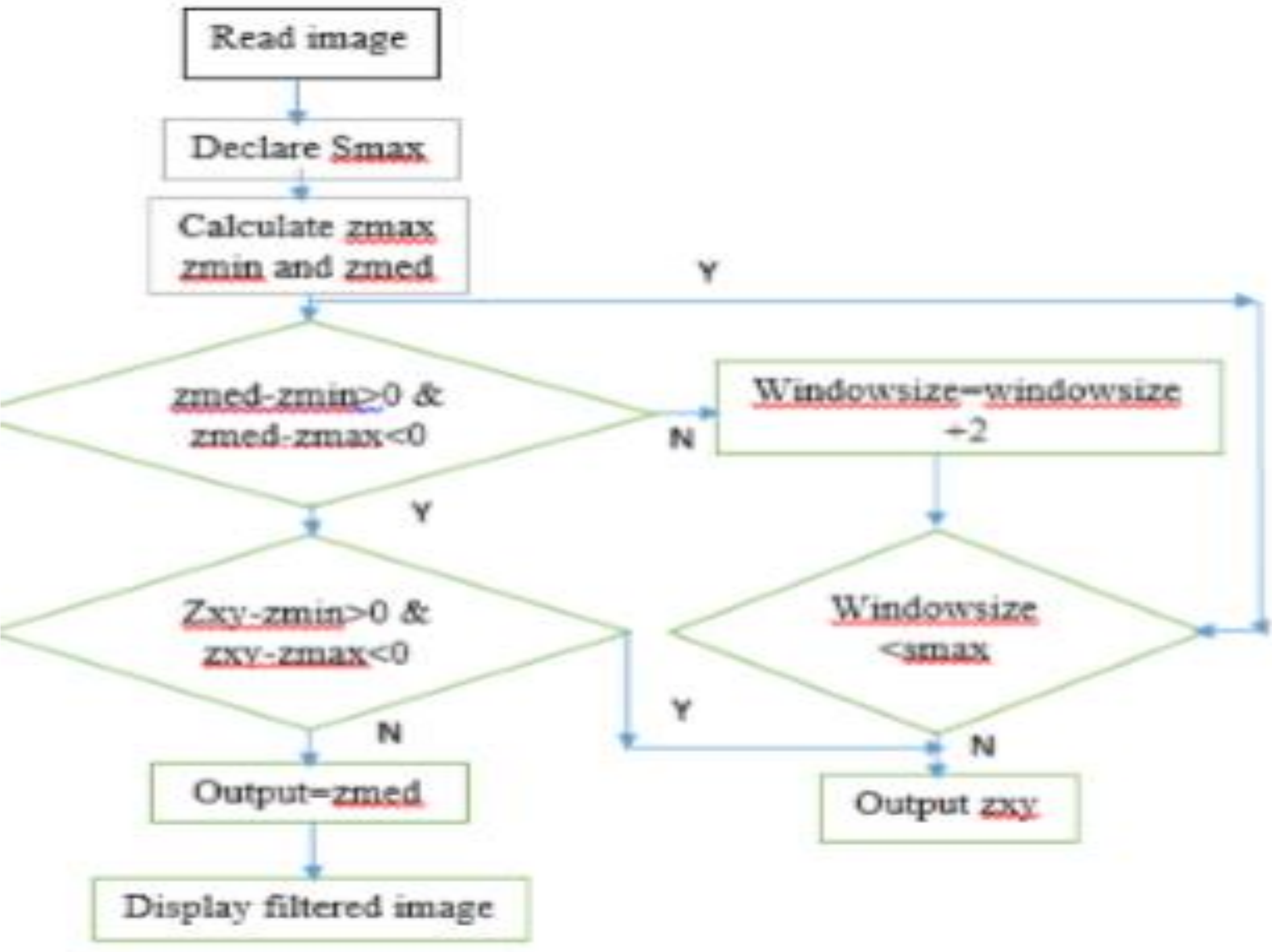


Fig: flowchart of adaptive median filter

Where,
Sxy= size of the neighbourhood
Zmin =minimum gray level value in Sxy
Zmax=maximum gray level value in Sxy
Zmed=medianofgray levels in Sxy
Zxy=gray level at coordinate (x,y)
S_{max}=Maximum allowed size of S_{xy}

VI. EXPERIMENTAL RESULTS

25% of Salt and pepper noise is added to both the gray scale and the color images. Then average median and adaptive median filter techniques are applied to the respective noisy images and results are compared after de noising.

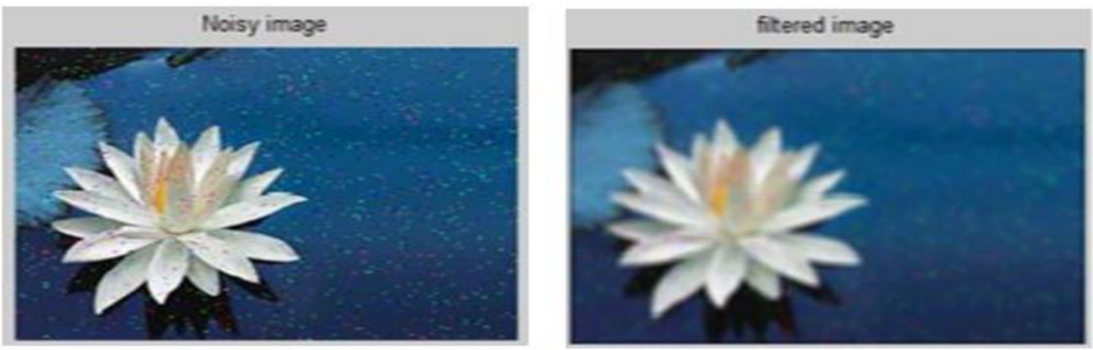
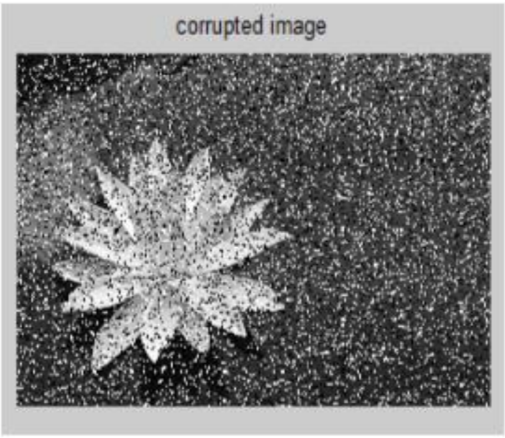


Fig-6 a) Noisy image 6 b) Filtered image for mean filter with salt and pepper noise of 25%.



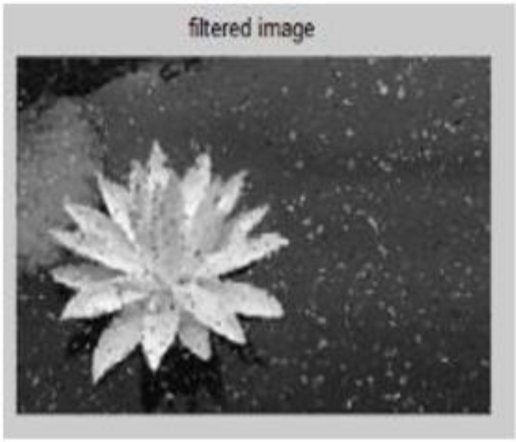
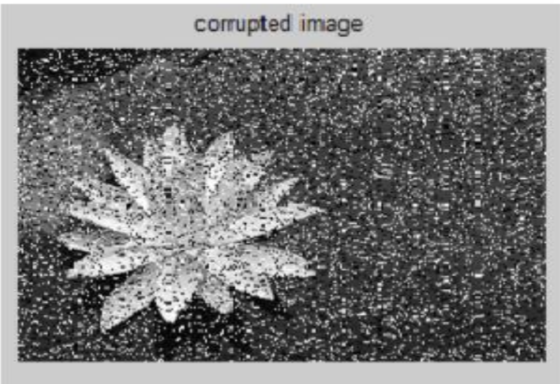


Fig 6c) Noisy image 6d) Filtered image for median filter with salt and pepper noise of 25%.



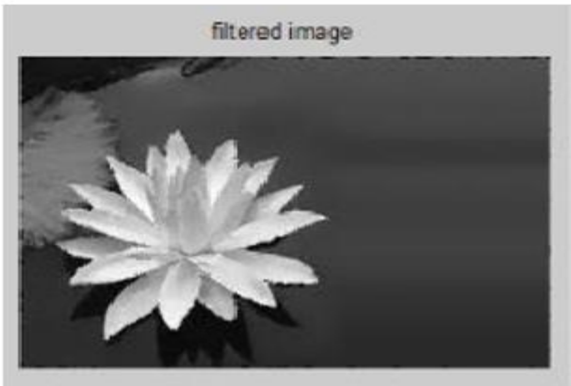


Fig 6e) Noisy image 6f) Filtered image for adaptive median filter with salt and pepper noise of 25%.

From the above figures, it is clear that the results of adaptive median filter is good when compared to mean filter and median filter with salt and pepper noise of 25%. Thus adaptive median filters work at high noise densities which is not possible with mean and median filters.

6.**1Comparison of Mean, Median and Adaptive median filter based on image quality metrics:**

Mean Square Error (MSE), MSE is computed by averaging the squared intensity of the original (input) image and the resultant (output) image pixels.

$$MSE = \frac{1}{NM}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1} e(m,n)^2$$

Where e(m,n) is the error difference between the original and the distorted images

Peak Signal-to-Noise Ratio (PSNR), Signal–to-noise ratio (SNR) is a mathematical measure of image quality based on the pixel difference between two images . The SNR measure is an estimate of quality of reconstructed image compared with original image.

$$PSNR = 10log\frac{s^2}{MSE}$$

Where s = 255 for an 8-bit image. The PSNR is basically the SNR when all pixel values are equal to the maximum possible value.

Parameters	Mean Filter	Median Filter	Adaptive Median Filter
MSE	53.291329	11.205920	3.442903
PSNR	30.864238 dB	37.636328 dB	42.761555 dB

Table 6.1 Comparison Table based on image quality metrics

Mean square error (MSE) and Peak signal to noise ratio (PSNR) for mean, median and adaptive median filter are compared. It can be seen that MSE for adaptive median filter is very less when compared to median and mean filter. And PSNR for adaptive median filter is high when compared to median and mean filter.

VII CONCLUSION

Different types of noise can occur during image acquisition or transmission in the image such as salt and pepper noise, Gaussian noise etc. To remove this type of noise, several noise removal techniques are employed such as mean filter, median filter, and adaptive median filter. The mean filter produces ablurred image and it does not work at high noise densities, hence median filter is used. The median filter produces better results compared to mean filter. However it does not remove noise at very high noise densities. Therefore we use adaptive median filtering that can handle impulse noise with probabilities even larger than these. An additional benefit of the adaptive median filter is that it seeks to preserve details while smoothing non impulsive noise. Considering the high level of noise, adaptive median filter performs quite well. Different types of image quality metrics are implemented for getting the quality of an image. MSE and PSNR for mean, median and adaptive median filter are calculated and quality of the image is analysed..

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