Performance Analysis of Average and Median Filters for De noising 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 de noising 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.*
***Key Words*: De noising, Impulse noise, Average and Median filters, MATLAB**

1. INTRODUCTION

Image Restoration techniques aim at reversing the degradation undergone by an image to recover the true image. Images may be corrupted by degradation such as linear frequency distortion, noise, blocking artifacts. The degradation consists of two distinct processes. They are noise and deterministic blur. The blur may be due to various reasons such as motion of the object being captured, defocusing and atmospheric conditions. The noise may originate in the image formation process, the transmission process, or a combination of both of them. Most restoration techniques model degradation process and attempt to apply an inverse procedure to obtain an approximation of the original image. Classical linear techniques restore the true image by filtering the observed image using a properly designed filter. Non-linear techniques do not explicitly implement the inverse; instead it uses an iterative approach to produce restoration until a termination condition is reached. This paper deals with non-linear filtering techniques for removal of noise.

1.1 IMAGE-RESTORATION MODEL

In the image restoration model, the input image is represented by f(m,n) and h(m,n) represents the degradation.

f ^(m,n)represents the restored image and ή(m,n) represents the noise.

The degraded image can be represented as

g(m,n)=h(m,n)*f(m,n)+ ή(m,n)--------1.1

h(m,n) is the degradation function.* symbol represents convolution operation.

Three cases can be discussed in this regard.

i) Only when degradation function is known

ii) Only when noise is present

iii) When both degradation &noise are known.

When the only degradation present in an image is noise,the degradation is modeled as

g(m,n)=f(m,n)+ ή(m,n)--------1.2

The estimate f ^ (m,n) should be as close as possible to the original image f(m,n).

2. NOISE AND ITS CHARACTERISTICS

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 and frequency 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.

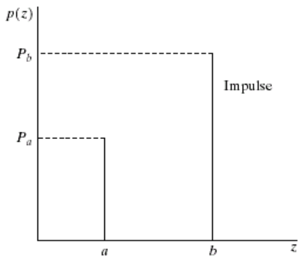
2.1 NOISE MODELS

Spatial noise is described by the statistical behavior of the gray level values in the noise component of the degraded image. Noise can be modeled as a random variable with a specific probability distribution function. Mostly widely used noise models are

- Impuse (Salt&Pepper) noise
- Gaussian noise
- Rayleigh noise
- Gamma noise
- Exponential noise
- Uniform noise

2.2 SALT& PEPPER NOISE

Salt &Pepper noise is also called Impulse noise. This noise can be caused by sharp& sudden disturbances in the image. Its appearance is randomly scattered on white or black (or both) pixels over the image.



$$p(z) = \begin{cases} P_a & \text{for } z = a \\ P_b & \text{for } z = b \\ 0 & \text{otherwise} \end{cases}$$

Fig 2.2 Salt and Pepper Noise Pdf

If either Pa or Pb is zero, the impulse noise is called unipolar, a and b usually are extreme values because impulse corruption is usually large compared with the strength of the image signal. It is the only type of noise that can be distinguished from others visually.

3. 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, which can be either linear filtering or non-linear filtering. The two main filters in those categories are i) Averaging or Mean filter
ii) Median Filter

3.1. AVERAGE FILTER

The average filter is a filter which uses a mask over each pixel in the image. Each of the components of the pixels which fall under the mask are averaged together to form a single pixel. This new pixel is then used to replace the pixel in the image studied. The Mean Filter is poor at maintaining edges within the image.

f^(x,y)=(1/MN) ∑ g(s,t)---------------(3.1)
(s,t)€Sxy

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 neighbors, including itself. This has 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 neighborhood 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.

$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$

Fig-3.1 3X3 Averaging kernel used in mean/average filter

3.2 MEDIAN FILTER

A Median filter is a non-linear filter and is efficient to remove impulse noise.Median tends to preserve the sharpness of image edges while removing noise.The Median Filter is performed by taking the magnitude of all of the vectors within a mask and sorting the magnitudes. The pixel with the median magnitude is then used to replace the pixel studied. The Simple Median Filter has an advantage over the Mean filter in that it relies on median of the data instead of the mean. A single noisy pixel present in the image can significantly skew the mean of a set. The median of a set is more robust with respect to the presence of noise.

f^(x,y)=median{g(s,t)}---------------(3.2)
(s,t)€Sxy

This filter replaces the value of pixel by the median of the gray levels in the neighborhood of that pixel. It has excellent noise-reduction capability for certain types of random noise with considerable less blurring than linear smoothing filters of similar size. This filtering technique is effective for both bipolar and unipolar impulse noise.

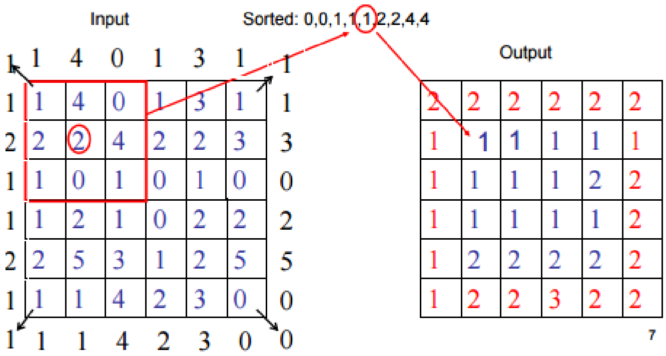


Fig3.2.1: 2D median filtering using a 3 X 3 sampling window

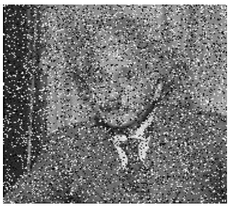
4. EXPERIMENTAL RESULTS COMPARISON

10% and 20% Salt and pepper noise is added to both the gray scale and the color images. Then Average and Median

filter techniques are applied to the respective noisy images
and results are compared after de noising.

4.1 RESULTS OF PERFORMING AVERGE FILTER ON GRAY SCALE IMAGE

i) a) Noisy image b) 3x3 filtered image

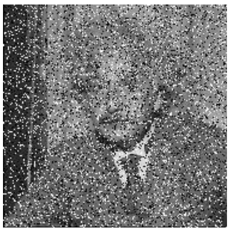


ii) **a)** Noisy image b) 5x5 filtered image

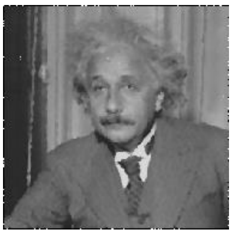
iii) a) Noisy image b)7x7 filtered image

4.2. RESULTS OF PERFORMING MEDIAN FILTER ON GRAY SCALE IMAGE

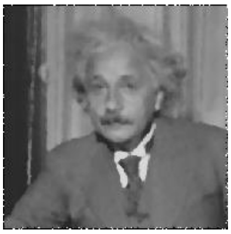
i) A) Noisy image B) 2x2 filtered image



ii) A) Noisy image B) 4x4 filtered image



iii) A) Noisy image B) 6x6 filtered image

iv) A) Noisy image B) 8x8 filtered image

v) A) Noisy image B) 10x10 filtered image

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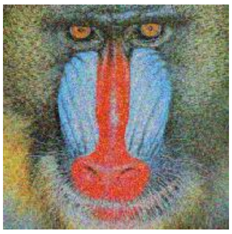
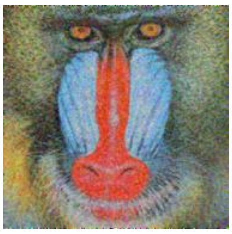
4.3 RESULTS OF PERFORMING AVERGE FILTER ON COLOR IMAGE

i) a) Noisy image b) 3x3 filtered image

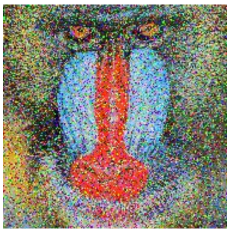
ii) a) Noisy image b) 5x5 filtered image

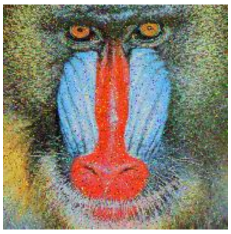
 

iii) a) Noisy image b)7x7 filtered image

4.4 RESULTS OF PERFORMING MEDIAN FILTER ON COLOR IMAGE

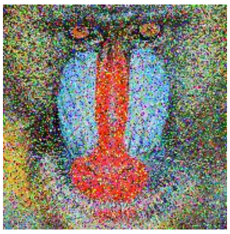
i)) A) Noisy image B) 2x2 filtered image



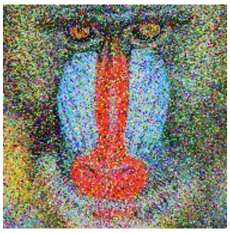


ii)) A) Noisy image B) 4x4 filtered image

iii) A) Noisy image B) 6x6 filtered image



iv) A) Noisy image B) 10x10 filtered image



5. CONCLUSION

By comparing the above results for 3x3, 5x5, 7x7 Averaging filters it is found that the noise has been removed, and at the same time the image has got blurred. As the size of the window increases, the ability to remove noise increases at the expense of blurring of the image.

The effect of increasing the size of the window in median filtering is shown in the above results. By comparing it is found that noise is removed effectively as the size of the window increases. Also the ability to suppress the noise increases only at the expense of blurring of edges.

In this paper Average and Median filter results are compared and it is found that Median filter is efficient in removing salt and pepper noise. It preserves the sharpness of image edges while removing noise.

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