A Comparative Study on Noise Models and Filtering Techniques in Images

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Abstract – Digital image processing involves the modification of digital data for improving the image quality using computer. Digital images are generally prone to different types of noises which are undesirable. Noise in digital images may arise during image acquisition (digitization) or during image transmission. The performance of image sensor is affected by variety of reasons such as environmental condition during image acquisition or by the quality of the sensing element themselves. Images are corrupted during their transmission through the channel . Removal of noise from the images is a challenge these days and many techniques like filtering are being followed for de-noising the image. The principal purpose of filtering or de-noising the image is to recover the details of the original image as much as possible. The type of noise present in the image determines the noise removal algorithms to remove the noise. Different approaches for reduction of noise and image enhancement have been considered, each of them have their own advantages and limitations.

Index Terms - Gaussian noise, Gamma noise, Poisson noise, Speckle noise, Mean filter, Median filter, Adaptive Wiener filter, HMMF

I. INTRODUCTION

An image basically is a two dimensional function whose value or amplitude at each point is called the GRAY LEVEL or INTENSITY LEVEL at that point. It is a collection of a finite number of elements, which are referred to as PIXELS. Noise is introduced in the image at the time of image acquisition or transmission. Different factors may be responsible for introduction of noise in the image. The number of pixels corrupted in the image will decide the quantification of the noise.

The principal sources of noise in the digital image are:

- The imaging sensor may be affected by environmental conditions like temperature
- Insufficient Light levels and dust on the screen of camera may introduce the noise in the image.
- Interference in the transmission channel may also corrupt the image.

During image acquisition or transmission, several factors are responsible for introducing noise in the image. Depending on the type of disturbance, the noise can affect the image to different extent. So we identify certain kind of noise and apply different algorithms to remove the noise.

Image noise can be mainly classified as SPECKLE NOISE , GAUSSIAN NOISE, GAMMA NOISE, POISSON NOISE.

Image de-noising is a vital image processing. There are many ways to filter an image or a set of data. The important property of a good image de-noising model is that it should completely remove noise as far as possible while keeping edges intact. Traditionally, there are two types of filtering techniques i.e. linear filtering and non-linear filtering. Generally, linear filtering techniques are used. The benefits of linear noise removing techniques is the speed and the limitations are, that it is not able to preserve edges of the images in a efficient manner i.e. the edges, which are recognized as discontinuities in the image, are smeared out and fails to remove tailed distribution noise. On the other hand, Non-linear filtering techniques can handle edges in a much better way than linear models and has efficient noise attenuation with robustness against impulsive type noise.

II. NOISE TYPES

Picture noise can be principally delegated SALT and PEPPER NOISE, GAUSSIAN NOISE, POISSON NOISE and SPECKLE NOISE.

A. Salt & Pepper Noise - Highly contrasting dots show up in the picture because of this noise and thus salt and pepper noise. [12]This type of noise emerges in the picture due to sharp and sudden changes of picture signal.

B. Gaussian Noise - The term normal noise model is the synonym of Gaussian noise. This noise model is additive in nature and follow Gaussian or Normal distribution. Meaning 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. The PDF of Gaussian arbitrary variable is given by the eq.(2)

$$P(x) = \frac{1}{\sigma(\sqrt{2\pi})} e^{\left(\frac{(x-\mu)^2}{2(\sigma^2)}\right)} \tag{2}$$

Where P(x) is the Gaussian distribution noise in picture, μ and σ is the mean and standard deviation separately.

C. Poisson Noise - [4]Some of the reasons are Poisson or shot photon noise is the noise that can cause, when number of photons detected by the sensor is not adequate to give distinguishable factual data. This noise has root mean square value proportional to square root intensity of the image. Different pixels are suffered by independent noise values. At practical grounds the photon noise and other sensor based noise corrupt the signal at different proportions

D. Speckle Noise - This noise can be demonstrated by arbitrary values increases with pixel estimations of the picture and communicated by an eq.(3)

$$J=I+n*I \tag{3}$$

Where J is the speckle noise circulation of a picture, I is the information picture and n is the uniform noise picture by zero mean and variance v. Further different noise models in a picture of micro-algae followed in underneath Fig. 4

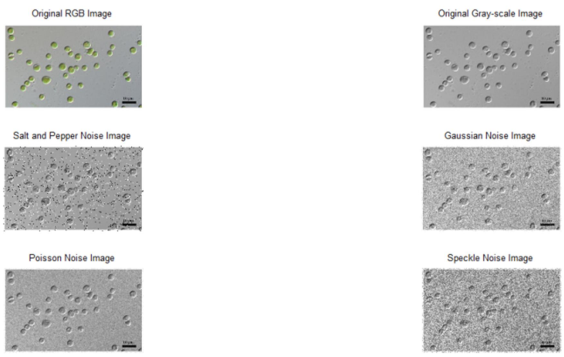

Fig. 4 Noise Outputs of Various Noise Models

III. FILTER TYPES

[13]Finally, the accompanying Fig. 5 demonstrates the essential model of filter description as underneath

Fig. 5 Basic Block Setup for Filter Description

Where g(x,y) is the noise corrupted image and f(x,y) is the filtered image.

a. Mean Filter

Mean filter is a simple effortless spatial filter that employs sliding window technique to replace central value in the window. It is an averaging linear filter that calculates average value of corrupted image in a pre decided area. The central pixel intensity value is replaced by the mean value of all pixel values in kernel or window. The kernel or window is usually square but can be of any type.The accompanying Table 1 and 2 demonstrates an outline of mean filer with 3X3 portion.

Table 1: Illustration of Mean Filter with 3X3 Kernel Mask

Unfiltered Values		
8	4	7
2	1	9
5	3	6

4+9+8+7+2+3+6+5+1=45
45/9=5

Table 2: Replacement of Unfiltered Values by Mean Value

Mean Filtered		
*	*	*
*	5	*
*	*	*

However, the mean filter have different preferences like simple to execute, basic in annihilation of wanted noises. Be that as it may, on other hand includes certain restriction like does not preserve particulars of an image. The accompanying Fig. 6 demonstrates an execution of mean filter for different noise models as underneath

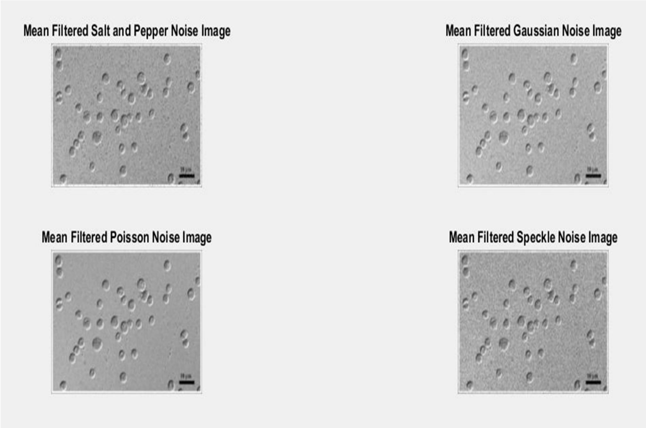

Fig. 6 Performance of Mean Filter for Various Noise Models

b. Median Filter

Median filter is a best order static, non-linear filter, whose reaction depends on the positioning of pixel values contained in the filter locale. It is anything but difficult to execute strategy for smoothing pictures. The median filter gives best outcome when the impulse noise rate is under 0.1 %. At the point when the amount of drive noise is expanded the median filter not gives best outcome. The accompanying Table 3 demonstrate the median filter process whose focal estimation of 80 is replaced by 11 as beneath

Table 3: Median Filter Characteristics with value 11

	10	5	20				
	14	80	11				
	8	3	22				

Median Filtered Values:3,5,8,10,11,14,20,22,80

Facilitate the Fig. 7 demonstrates the execution of the median filtered pictures for various noise models as underneath

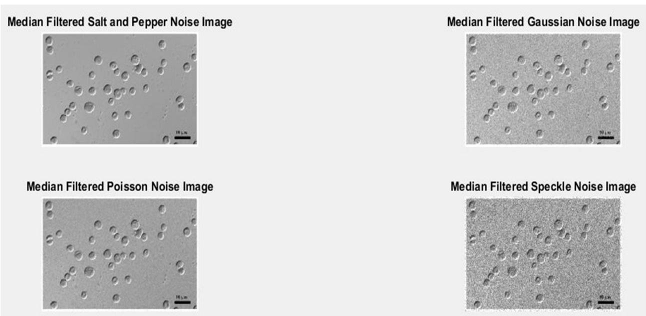

Fig. 7 Performance of Median Filter for Various Noise Models

c. Wiener Filter

The purpose of the Wiener filter is to filter out the noise that has corrupted a signal. This filter is based on an arithmetic approach. Mostly all the filters are designed for a desired frequency response. Wiener filter deals with the filtering of an image from a different view. The goal of wiener filter is reduce the mean square error as much as possible. This filter is capable of reducing the noise and degrading function. One method that we assume we have knowledge of the spectral property of the noise and original signal. We have used the linear time Invariant filter which gives output similar as to the original signal as much possible.The Fourier space of the wiener channel is appeared in the beneath eq.(4)

$$G(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 Ps(u,v) + Pn(u,v)} \qquad (4)$$

Where H*(u,v) is the unpredictable conjugate of corruption work, Pn(u,v) is the power ghastly thickness of commotion, Ps(u,v) is the power ghastly thickness of non-debased picture H(u,v) is the corruption work.

Further, the accompanying Fig. 8 demonstrates the execution of the wiener filter for different noise models as beneath

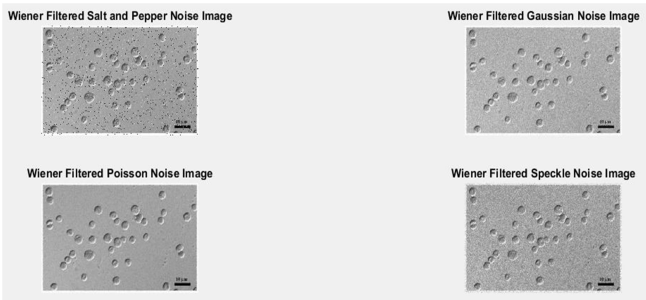

Fig. 8 Performance of Wiener Filter for Various Noise Models

d. HMMF Filter

HMMF filter is a hybridization of cross breed max filter and half breed min filter. It is utilized for evacuating the salt and pepper noise from a picture generally broadly. Such channel can be communicated utilizing an eq.(5)

$$\mathrm{g(p)} = \min \left\{ \begin{array}{c} median\{f(q), q \in L_3(p)\}, \\ median\{f(q), q \in R_3(p)\}, \\ f(p) \end{array} \right\}$$

$$h(p) = max \left\{ \begin{array}{c} median\{g(q), q \in L_3(p)\}, \\ median\{g(q), q \in R_3(p)\}, \\ g(p) \end{array} \right\} \qquad (5)$$

In this filter the information picture is prepared by cross breed min filter (H2F) and yield of it is handled by half breed max filter (H3F). Along these lines, the accompanying Fig. 9 plainly delineates the execution of the Hybrid Filtered for different noise models as demonstrated as follows

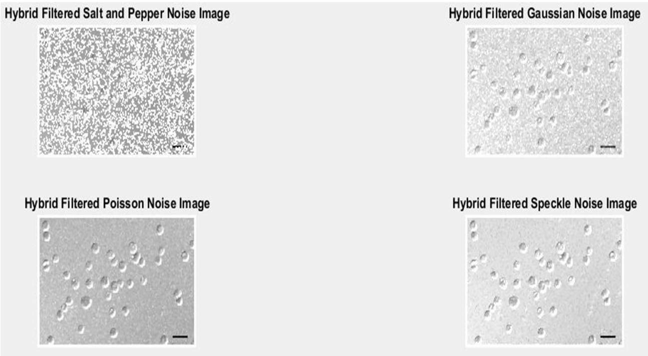

Fig. 9 Performance of HMMF for various Noise Models

IV. COMPARITIVE ANALYSIS

So the nature of the noise lessening in pictures is measured by the factual amount measures, for example, Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR). Henceforth, the accompanying Fig. 10 and 11 demonstrates the bar diagram of those two factual parameter measures in a similar situation of different Filtered Noise Images of HMIS based Microalgae pictures separately.

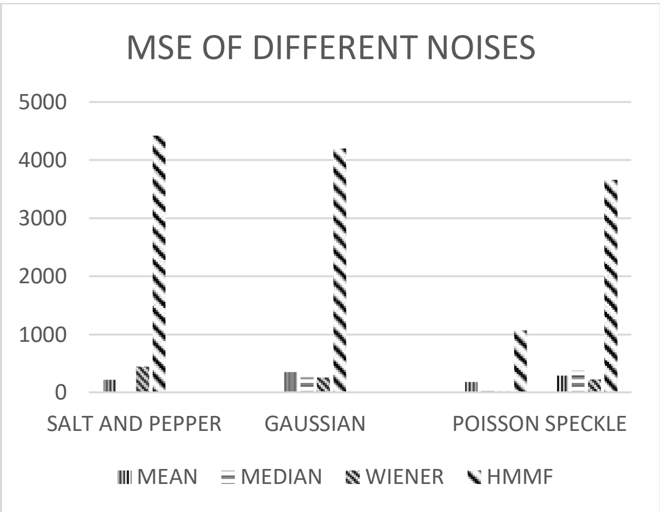

Fig. 10 Bar Chart of MSE of various Filtered Noise Models

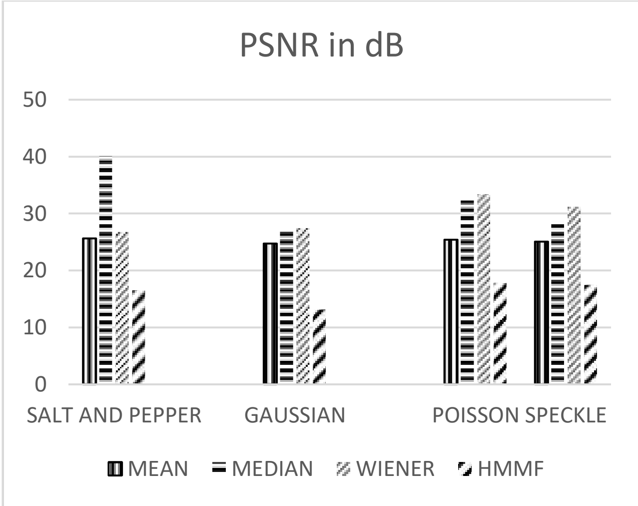

Fig. 11 Bar Chart of PSNR of various Filtered Noise Models

Therefore, the improvement of an uproarious picture is vital and essential assignment in computerized picture preparing. Since, different filters are utilized for expelling noise from the pictures. In this paper, we portray four primary filters procedures for noise removal. Therefore from the diagrams acquired, it is seen that HMMF is best in light of factual measure of qualities.

V. CONCLUSION

Enhancement of a noisy image is necessary and important task in digital image processing. Filters are used best for removing noise from the images. After studying linear and non-linear filter which have their own limitations and advantages and also from graphs obtained, it is seen Median Filter is best based on the PSNR and MSE values.

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