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A Survey on different Filters for Noise Reduction in Digital Images

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Abstract: Image processing still faces the challenge of reducing noise from images. Noise is always present in digital images during image acquisition, coding, transmission and processing steps. Noise is very difficult to remove from digital images without the prior knowledge. Image processing proves to be very successful in permitting and extended range of algorithms to be applied to input data set in the form of image and regain decisive results. These algorithms lean to avoid problems such as noise and signal distortion. So, in this paper, we express a brief overview of various noise models and the survey on filters which are used to remove the noise from the images. By using these filters we can achieve an image after noise removal which having higher clarity in terms of both interpretation and analysis for study in different fields and this paper is to be analyzed the filters those are Mean, median ,adaptive median and wiener filter used to reduce noises such as Gaussian, Salt and pepper and Speckle noise.
Keywords: Noise images, Types of noises, Noise reduction by using filters

I. INTRODUCTION

The major extend omission of an image is existence of noise. It refers to the random variation of intensity of a pixel, which modifies the actual information of an image. as a result, pixels which appear in the image are not the actual pixels. Addition of extraneous values to the image causes the occurrence of noise i.e., unwanted signals leading to challenging analysis of image. Mostly, noise is categorized into these types such as Gaussian noise, speckle noise, salt & pepper noise. The extraction of these noises from the original image is a de-noising process which makes interpretation and analysis easier. The process of de-noising is accomplished by filtering the superfluous noise and highlights the features and excellence of an image. For the process of de-noising, we are using filters which helps in providing image enhancement. This facilitates achieves various processes such as interpolation and re-sampling. Depending upon the type of filter to be used for the analysis. In this paper, we are using the following filters namely mean filter, median filter, adaptive median filter and wiener filter. Median filter is widely used as,it is very effective at removing noise while preserving edges and it is particularly effective at removing 'salt and pepper' type noise. The mean filter is a simple sliding window spatial filter that replaces the center value in the window with the average of all the pixel values in the window. The adaptive filter used to changing the signal characteristics, it increases speed and complexity, and reducing power consumption. The wiener filter is used for the removal of blur and noise in images due to linear motion (or) unfocussed optics. In this paper, we compare the performance of the above mentioned filters in the presence of noise.

II. NOISE MODELS IN IMAGES

The unwanted signal in an image may be referred as noise. Image noise is random variation of brightness or colour information in images and is usually an aspect of electronic noise. It can be produced by the sensor and circuitory of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of C.

1) *Gaussian Noise:* Gaussians noise is also called as electronic noise because it arises in amplifiers or detectors. It is caused by natural sources such as thermal vibration of atoms and discrete nature of radiation of warm objects. Gaussian noise generally disturbs the gray values in digital images because of the mathematical tractability in both the spatial and frequency domains, Gaussian noise models is so convenient that it often results in Gaussian models being used in situations in which they are marginally applicable at best that is why Gaussian noise model essential designed by its "probability distribution function" is

$$p(z) = \frac{1}{\sqrt{(2\pi)}\sigma} e^{-(z-\mu)^2/2\sigma^2} \quad \text{......................eq(1)}$$

This is the probability of distribution function of Gaussian noise.

2) *Salt and Pepper Noise:* The is also called data drop noise because statistically its drop the original values. This noise also referred as "Impulse noise". However the image is not fully corrupted by Salt and Pepper noise instead of some pixel values are changed in the image. Although in noisy images, there is a possibilities of some neighborhoods not changed. Generally , we can see this noise in data transmission image pixel values are replaced by corrupted pixel values either maximum or minimum pixel value this noise occurs when there exist dark pixels in bright region and vice versa. These unexpected disturbance in image signal causes to Salt and Pepper noise.

$$p(z) = \begin{cases} P_a & \text{for } z = a \\ P_b & \text{for } z = b \\ 0 & \text{otherwise} \end{cases} \quad \text{.....................…. eq(2}$$

This is the "probability distribution function" of Salt and Pepper noise.

3) *Speckle Noise:* Speckle noise is a multiplicative noise and it is primitive noise. Their presence is seen in sensible (coherent) image. System such as LASAR, RADAR and acoustics etc….. this noise occurs due to modeling of reflectivity function. Existence of Speckle noise can exist similar to Gaussians noise ultra sound images mostly get computed because of speckle noise . this noise having granular patterns mathematically speckle noise is expressed as

$$g(m,n) = f(m,n)*u(m,n)+\epsilon(m,n) \quad \text{……..…………………… eq(3)}$$

Its probability distribution function follows the gamma distribution as given as

$$F(z) = z^{\alpha-1}/(\alpha-1)!a^{\alpha}\,(e^{-(z/a)}) \quad \text{……..…………………...eq(4)}$$

III. FILTER MODELS

1) *Mean Filter:* mean 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 image.

2) *Arithmetic Mean Filter:* let S_{XY} represent the set of coordinates in rectangular sub image window of size m×n, centered at point(x,y) . The arithmetic mean filter computes the average value of the computed image g(x,y) in the area is defined by S_{xy} . The value of restored image f^ at point (x,y) is simply the arithmetic mean computed using the pixels in the region defined by S_{xy}

$$\hat{f}(x,y) = \frac{1}{mn}\sum_{(s,t)\in S_{xy}} g(s,t) \quad \text{…………………………..eq(5)}$$

The operation can be implemented using a spatial filter of size m×n in which all coefficients have value 1/mn .

A mean filter smooth local variations in an image, noise is reduced as a result of blurring.

3) *Median Filter:* The median filter is a non-linear digital filtering technique , often used to remove noise from an image(signal) such noise reduction is atypical pre-processing step to improve the results of later processing . Median filtering is very widely used in image processing because , under certain conditions , it is preserves edges while removing noise. The best known order statistic filter is the median filter, which as its name implies ,replaces the value of a pixel by the median of intensity levels in the neighborhood of that pixel

$$\hat{f}(x,y) = \underset{(s,t)\in S_{xy}}{median}\{g(s,t)\} \quad \text{…………………………equ(6)}$$

The value of the pixel at(x,y) is included in the computation of the median median filters are quite popular because for Certain types of random noise ,they provide excellent noise reduction capabilities , which considerably less blurring than Linear smoothing filters of similar size. Median filters are particularly effective in the presence of both bipolar and unipolar Impulse noise, in fact the median filter yields excellent results for images corrupted by this type of noise.

4) *Adaptive Median Filter:* The adaptive median filtering can handle "impulse noise" with probabilities larger than these additional benefit of the adaptive median filter is that it seeks to preserve detail while smoothing non-impulse noise ,smoothing that the "traditional" median filter does not do. The adaptive median filter also works in a rectangular window area S_{xy} . The adaptive median filter changes the size S_{xy} during filter operation on certain conditions. The output of the filter is a single value of the pixel at (x,y),the point on which the window S_{xy} is centered at a given time.

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Z_{min} = minimum intensity value in S_{XY}
Zmax = maximum intensity value in SXY
Zmed = median of intensity value in Sxy
Z xy = Intensity value at coordinate (x,y)
S_{xy} = maximum allowed size of S_{xy}

The adaptive median filtering algorithm works on two stages denoted as Stage-A and Stage- B . The key to Understanding of this algorithm is to keep in mind that it has three main purposes, to remove Salt and Pepper noise to provide smoothing of other noise that may not be impulsive , and to reduce distortion such as excessive thinning or thicking of object boundaries.

5) *Wiener Filter:* Wiener filter exploits the previous knowledge of the spectral properties of the original signal and the noise and linear time- invariant rule to produce an output as close to the original image as feasible, in wiener filtering.It is presumed that the signal and noise are static linear stochastic processes with familiar spectral properties. Wiener filter tries to reconstruct degraded image by minimizing an error function as designed by the following equation:-

$$MSE = E[\{f(x,y)-f\text{^}(x,y)\}^2] \qquad \text{..................equ(7)}$$

Where,

MSE = Mean square error
E = The expected operation
f^(x,y) = Restored image

The wiener filter is to locate an approximation µ(x,y) of the original image f(x,y) so as to the mean square error between them Is minimized wiener filter is represented as L(u,v) as shown below

$$L(u,v) = (H^*(u,v)\ S_f(u,v))/(|H(u,v)|^2 S_f(u,v)+S_n(u,v))$$
$$= H^*(u,v)/(|H(u,v)|^2+(S_n(u,v) / S_f(u,v))$$

Again

$$L(u,v) = (H^*(u,v)\ S_f(u,v)) / (|H(u,v)|^2 S_f(u,v)+S_n(u,v))$$
$$=(1/H(u,v))(|H(u,v)|^2/(|H(u,v)|^2+k)$$

Where,

$K = (S_n(u,v) / S_f(u,v))$
$S_f(u,v)$ = power spectrum of the original image
$S_n(u,v)$= Noise power spectrum

Here 'K' is the inverse of SNR. The image and noise are considered as arbitrary process. The wiener filter can generate optimal estimate only if such stochastic process are stationary Gaussian. These situations are not typically satisfied for real image so the restored image can be expressed as

$$f\text{^}(u,v) = L(u,v)\ G(u,v). \qquad \text{.................equ(8)}$$

IV. EXPERIMENTAL RESULTS

The work is executed on MATLAB Software with various images. The original images are of size 512x512,taken from the internet source. First the different types of noise removal filters are mentioned in the previous section are applied to the images and then the performance of different filters are Analyzed .

A. Reduction of Gaussian Noise (Using Different Filters)

Input Image 1

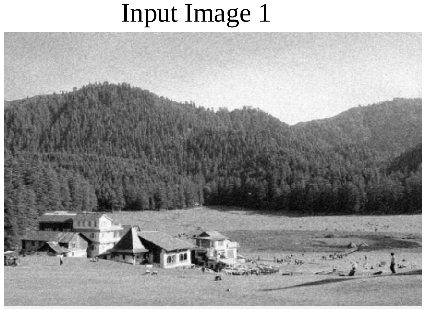
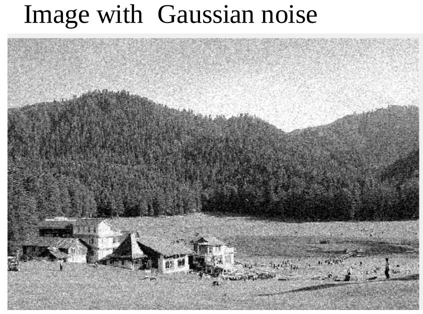
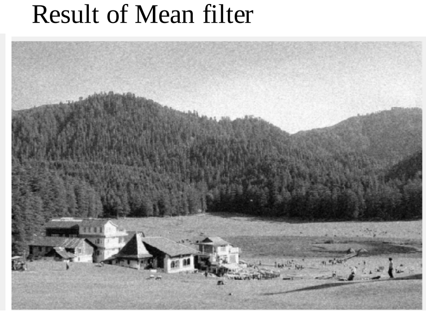


Image with Gaussian noise



Result of Mean filter



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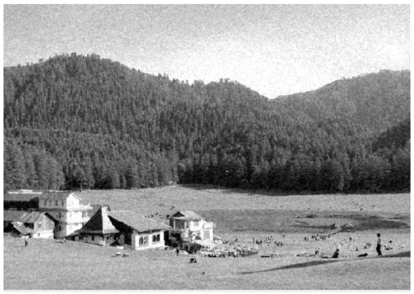
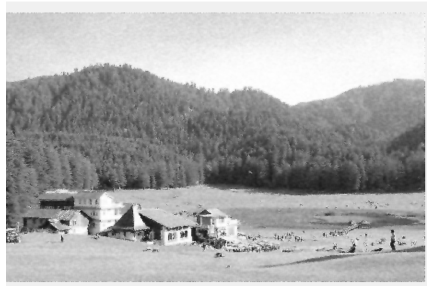
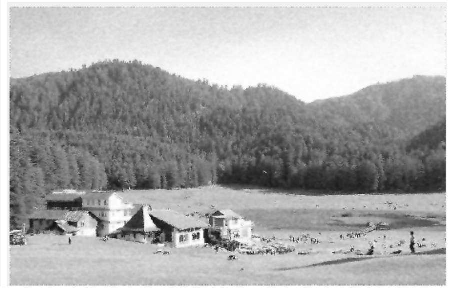
Result of Median filter



Result of Adaptive median filter

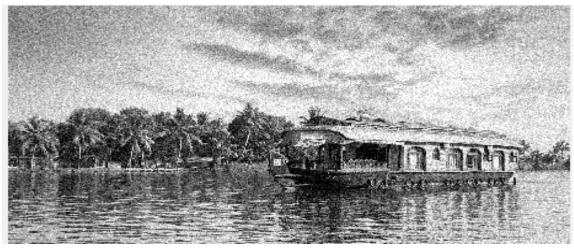


Result of Wiener filter



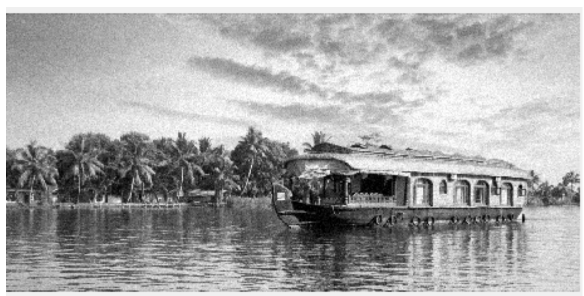
Input Image 2

Image with Gaussian noise

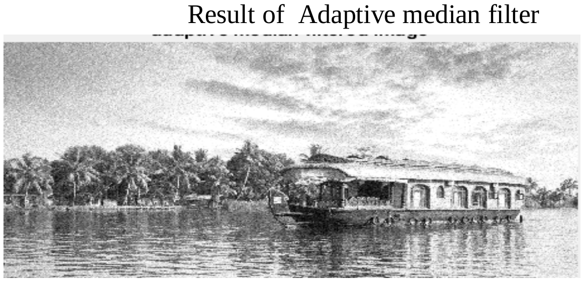


Result of Mean filter

Result of Median filter



Result of Adaptive median filter

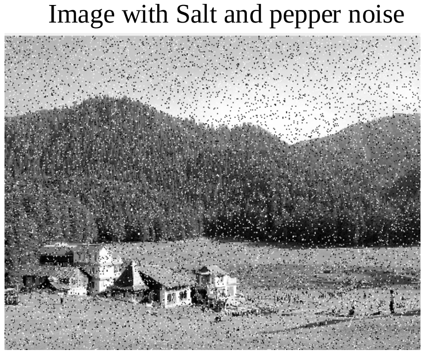


Result of wiener filter

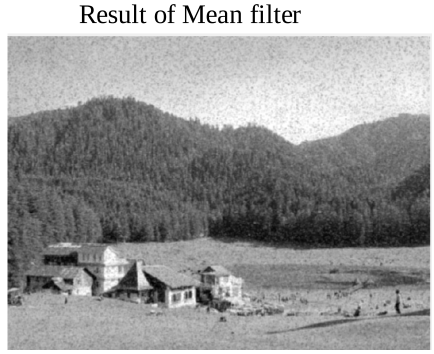
B. Reduction Of Salt And Pepper Noise (Using Different Filters)

Input image 1

Image with Salt and pepper noise



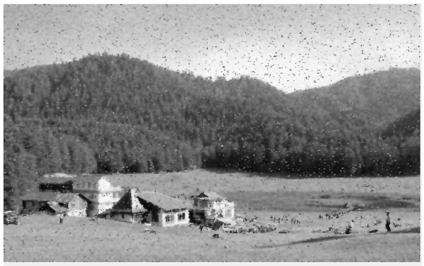
Result of Mean filter



Result of Median filter

Result of Adaptive Median filter

Result of Wiener filter



Input image 2

Image with Salt and pepper noise

Result of Mean filter

Result of Median filter

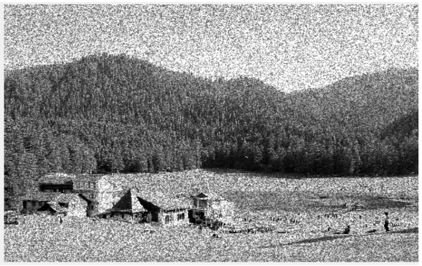
Result of Adaptive median filter

Result of Wiener filter

C. Reduction of Speckle Noise (Using Different Filters)

Input Image 1

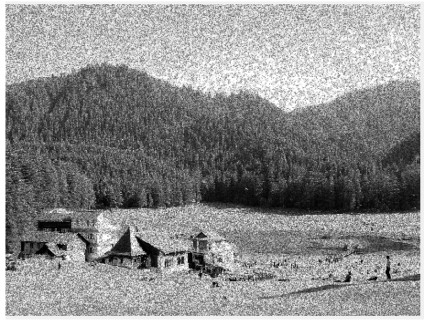
Image with Speckle noise



Result of mean filter

Result of Median filter

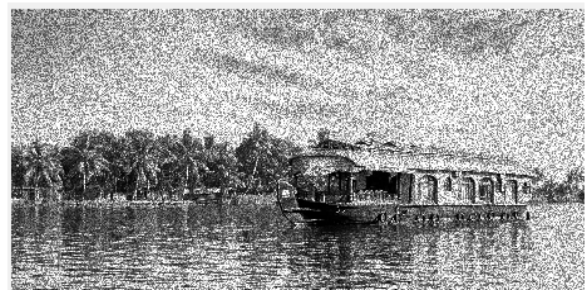
Result of Adaptive median filter



Result of wiener filter

Input Image 2

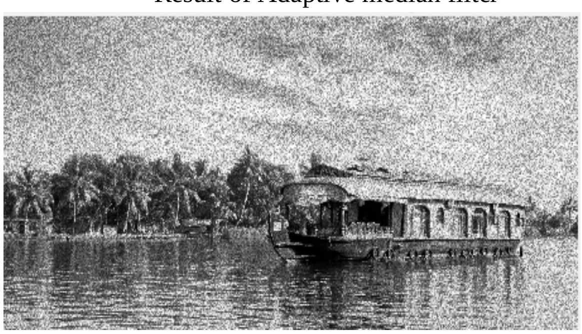
Image with Speckle noise



Result of Mean filter

Result of Median filter

Result of Adaptive median filter



Result of wiener filter

V. CONCLUSION

In this paper, we have discussed different types of noise that creep in images during image acquisition and transmission and also studied about the various filtering techniques used to de noising the images. It was clearly observed that the resultant images are produced better results when compared to the noisy images. Mainly The median and adaptive median filters gives better results compared to other filters. Future work focus on extending the algorithms by using advanced methods to improve the results.

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