Image Denoising using Linear and Non-linear filters

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ABSTRACT

A very large portion of digital image processing is devoted to image restoration. Image denoising is the manipulation of the image data to produce a visually high quality image. Different noise models include noise as additive and multiplicative type. They include Gaussian noise, salt and pepper noise, Brownian noise and speckle noise. Denoising algorithm is application dependent i.e. the application of a specific filter is beneficial against a specific kind of noise. In this paper, the filtering approach has been opted when the image is corrupted with salt and pepper noise. There are various filters which can remove the noise from images and preserve image details. Generally different filters are used for eliminating different noises like Mean filter removes the impulse noise, Median filter removes "salt and pepper" noise and Weiner filter removes noise that has corrupted a signal. It is based on a statistical approach. In this paper, we have suggested that Median filter provides best results against impulsive noise i.e. salt and pepper noise.

Key words: Image Denoising, Salt and Pepper Noise, Gaussian Noise, Median filter, Weiner filter.

I INTRODUCTION

Digital images are playing a prominent role in research and technology such as environmental information systems. Images often contain noise, which may arise due to sensor imperfections, poor illumination or communication errors. Removing such noise is of great benefit in many applications, and this may explain the vast interest in this problem and its solution.

Degrading noise, which are incurred during the image capturing process must be removed or reduced by denoising methods to improve the quality of the image. A very large portion of digital image processing is devoted to image restoration. This includes research in algorithm development and routine goal oriented image processing. Image restoration is the removal or reduction of degradations that are incurred while the image is being obtained. Degradation comes from blurring as well as noise due to photometric and electronic sources. Blurring is a form of bandwidth contraction of the image caused by the imperfect image formation process such as relative motion between the camera and the original scene or by an optical system that is out of focus.

A noise is introduced in the transmission medium due to noisy channel, errors during the measurement process and during sampling and quantization of the data for digital storage (in the form of arrays).

The objective of image restoration procedures is to suppress degradation of the image with the help of the knowledge about its nature. The image degradation could be attributed to the defects present in the optical lenses, relative motion between the object and the camera, wrong focus, turbulence in the atmosphere, scanning quality etc. The goal of image restoration is to reconstruct the original image from its degraded form.

There are many schemes for removing noise from images. The good denoising scheme must able to retrieve as much of image details even though the image is highly affected by noise. In common there are two types of image denoising model, linear model and nonlinear model. Generally linear model are being considered for image denoising, the main benefits of using linear noise removing models is the speed and the limitations of the linear models is the models are not able to preserve edges of the images in an efficient manner Non-linear models can preserve edges in a much better way than linear models but very slow.

II SCOPE OF THE PAPER

Visual information transmitted in the form of digital images is becoming a major method of communication in the contemporary age, but the image obtained after transmission is often degraded with noise. The received image needs processing before it can be used in applications. Image denoising involves the manipulation of the image data to produce a visually high quality image. This paper reviews the Noise models, Noise types and classification of image denoising techniques.

We have focused on the denoising of images using linear and nonlinear filtering techniques. Linear filtering is done using the mean filter and LMS adaptive filter while the nonlinear filtering is performed using a median filter. These filters are beneficial for removing noise that is impulsive in nature i.e. salt and pepper noise. The mean filters find applications where the noise is concentrated in the small portion of the image. Besides, implementation of such filters is easy, cost effective and fast. It can be observed from the output Images of Mean and LMS Adaptive filter that the filtered images are blurred. The median filter overcomes this problem by providing a solution to this, in which the sharpness of the image is retained after denoising. The result supports our approach towards median filter. Thus median filter is best among all the filters in filtering approach.

III LITERATURE SURVEY

Noise in the image may be introduced either during its formation or during its recording. The two separate processes that are likely to contribute to the noise in the images are random fluctuations in the number of photons and the photoelectrons on the photoactive surface of the detector and the random thermal noise which is generated in the circuit that senses the image acquires it and processes the signal from the detector's photoactive surface. Noise may also be introduced during the transmission of radiant energy.

3.1 Various Noise Models in Images

The images are degraded by noise which is some random error. Noise could be picked along with the image during capturing, transmitting or during the processing. It could be dependent or independent of the image content. Variety of noise models are used to create different types of noise for the images. The probabilistic characteristics of the noise can be used to describe it. The often used idealized noise, which is also called white noise, has the intensity that does not decrease with increasing frequency. A special case of white noise is Gaussian noise. Noise which is normally dependent of the images signal occurs when an image is transmitted through some channel. This signal independent degradation is called additive noise.

Quantization noise (Uniform noise) occurs when insufficient quantization levels are used Presence of impulse noise implies that an image is corrupted with individual noisy pixels whose brightness differs significantly from that of its neighborhood. The term salt-and-pepper noise is used to describe saturated impulse noise, i.e., an image corrupted with white and/or black pixels. Salt-and-pepper noise can corrupt the binary images.

Image Noise

Noise in images is caused by the random fluctuations in brightness or color information. Digital image noise may occur due to various sources. During acquisition process, digital images convert optical signals into electrical one and then to digital signals and are one process by which the noise is introduced in digital images. Due to natural phenomena at conversion process each stage experiences a fluctuation that adds a random value to the intensity of a pixel in a resulting image.

TYPES OF NOISE

Gaussian Noise

Gaussian noise is statistical in nature. Its probability density function equal to that of normal distribution, which is otherwise called as Gaussian distribution. In this type of noise, values of that the noise are being Gaussian-distributed. A special case of Gaussian noise is white Gaussian noise, in which the values always are statistically independent. For application purpose, Gaussian noise is also used as additive white noise to produce additive white Gaussian noise.

Salt and Pepper Noise

In salt & pepper noise model, there is only two possible values „a‟ and „b‟. The probability of getting each of them is less than 0.1 (else, the noise would greatly dominate the image). For 8 bit/pixel image, the intensity value for pepper noise typically found nearer to 0 and for salt noise it is near to 255. Salt and pepper noise is a generalized form of noise typically seen in images. An effective noise reduction algorithm for this type of noise involves the usage of a median filter, morphological filter. Salt and pepper noise occurs in images under situations where quick transients, such as faulty switching take place. This type of noise can be caused by malfunctioning of analog-to-digital converter in cameras, bit errors in transmission, etc.

Speckle Noise

In Speckle noise is a type of granular noise that commonly exists in and causes degradation in the image quality .Speckle noise tends to damage the image being acquired from the active radar as well as synthetic aperture radar (SAR) images. Speckle noise increases the mean gray level of a local area. Speckle noise is more serious issue, causing difficulties for image interpretation in SAR images.

Poisson Noise

Poisson noise is also known as shot noise. It is a type of electronic noise. Poisson noise occur under the situations where there is a statistical fluctuations in the measurement caused either due to finite number of particles like electron in an electronic circuit that carry energy, or by the photons in an optical device.

Brownian Noise

Brownian noise comes under the class of 1/f or fractal noises. The mathematical model for 1/f noise is fractional Brownian motion. Brownian noise is a special case of 1/f noise or fractal noises. It is obtained by mixing white noise with the image.

3.2 Image Denoising

The image s(x, y) is blurred by a linear operation and noise n(x, y) is added to make the degraded image w(x, y). w(x, y) is then convolved with the restoration procedure g(x, y) to generate the restored image z(x, y).

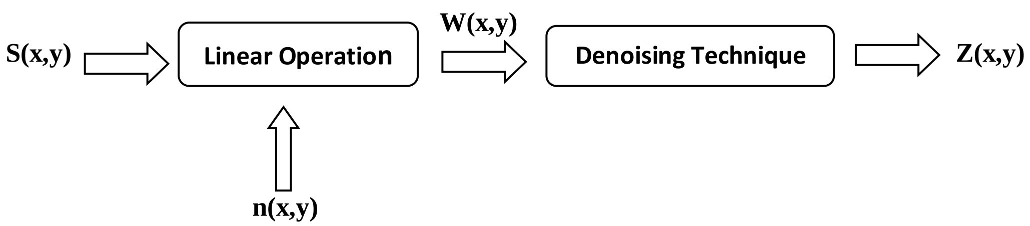


Figure 1: Linear operation on Image

The "Linear operation" shown in figure 1 is the addition or multiplication of the Noise n(x, y) to the signal or image s(x, y). Once the corrupted or noised image w(x, y) is obtained, it is subjected to the denoising technique i.e. algorithm to get the denoised image z(x, y). Noise removal or noise reduction can be done on an image by filtering, by wavelet analysis, or by multi fractal analysis. Each technique has its advantages and disadvantages.

Classification of Denoising Techniques

The basic idea of the determination of a non degraded image from the degraded or noisy image, and is referred to as image "denoising". Denoising method selection is based upon the type of image and noise model present in it. There are two fundamental approaches to image denoising.

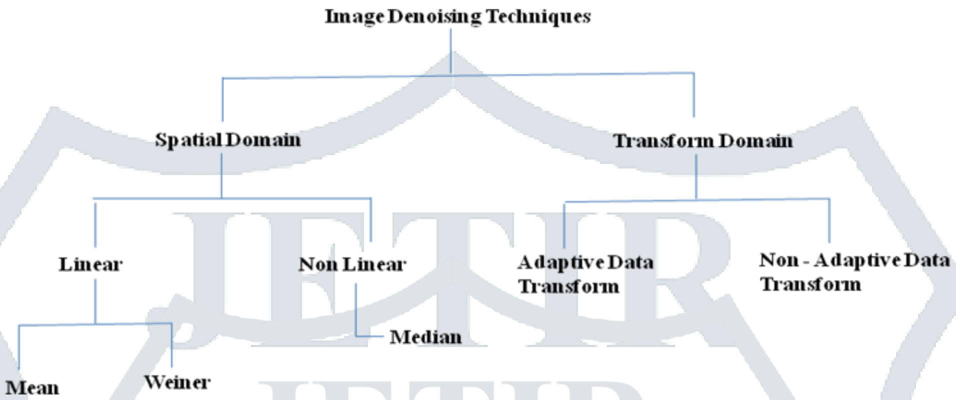


Figure 2: Classification of Image Denoising Techniques

3.3 Linear and Non-Linear Filtering Approach

Linear filtering is of two types: Mean filter and Least Mean Square (LMS) adaptive filter and nonlinear filtering is based on median filter.

3.3.1 Mean Filter

Mean filtering is a simple method of denoising images, i.e. reducing the amount of intensity variation between one pixel and the next. The basic idea of mean filtering is to replace each pixel value in an image with the mean (`average') value of its neighbors together with itself. This has the effect of eliminating pixel values which are unreliable of their surroundings.

3.3.2 Wiener Filter

By assessing the estimation of the enumerated silent gesture, it's wont to scale back the noises inside the signal. The Wiener filtering might be a linear estimation of the early picture. The way relies on a random structure.

3.3.3 Gaussian Filter

Gaussian eliminator square compute hypothetical to proposal no swarmed to a pace work contribution by cutting the rise and plummet time, by that minimum cluster stay is caused. Precisely, a Gaussian eliminator changes the input by alongside a Gaussian operate. The Gaussian filter is square compute utilized as a manipulation tool. The Gaussian filter's output is that the mean of the input.

3.3.4 Median Filter

The Median filter is a non-linear smoothing technique that reduces the blurring of edges; here the idea is to replace the current point in the image by the median of the brightness in its neighborhood. The median of the brightness in the neighborhood is not affected by individual noise spikes. The median filter eliminates impulse noise efficiently. Since median filtering does not blur edges much, it can be applied iteratively. One of the major problems with the median filter is that it is relatively expensive and is hard to compute. It is essential to sort all the values in the neighborhood into numerical in order to find out the median value which is relatively slow.

3.3.5 Average Filter

This is windowed filter of group, that smoothes gesture (image). The eliminator mechanism as low-pass the vital design at the back filter is for each portion of the gesture (image) seize a median crossways its area. The normal (mean) filter smoothes picture vision, so removing sound. This filter performs spatial filtering on every single individual constituent in a picture victimization the gray level benefits across a square or rectangular window close every single pixel.

IV SIMULATION RESULTS

We used MATLAB GUI environment for implementation since a good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls. The pictorial illustrations confer better understanding of the concepts with ease.

Figure3 give a overall GUI structure. An image can be selected from the browser and this is illustrated in figure4. In this paper we illustrated the results by using Salt & Pepper noise. Adding Salt & Pepper noise degrades the quality of the image. This is illustrated in figure5. Various filters are used to remove the added noise. We used Weiner filter, Median filter, Average filter, Disk filter and Gaussian filter. Figure 6 illustrates the removing the noise using Weiner filter. This paper also shows image histograms of original, noisy and filtered out images.

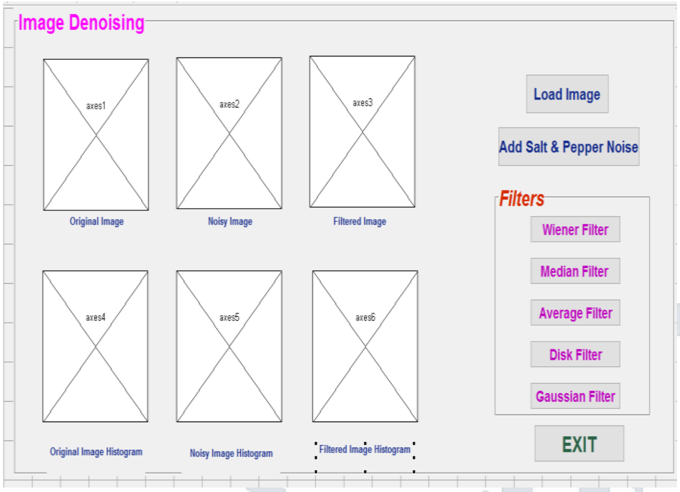


Figure 3: GUI Structure

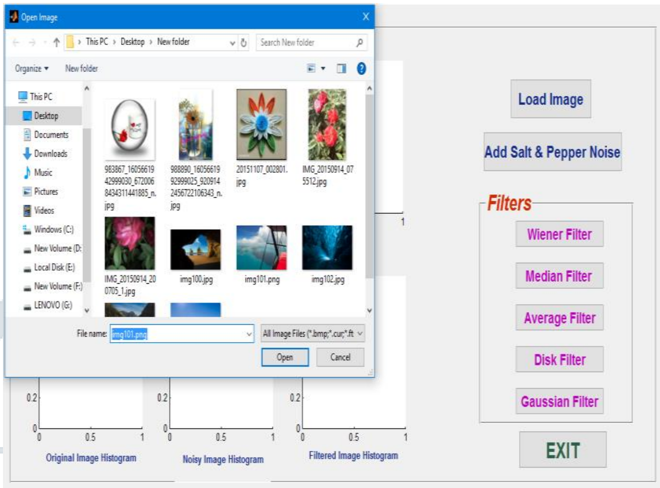


Figure 4: Loading of an Image

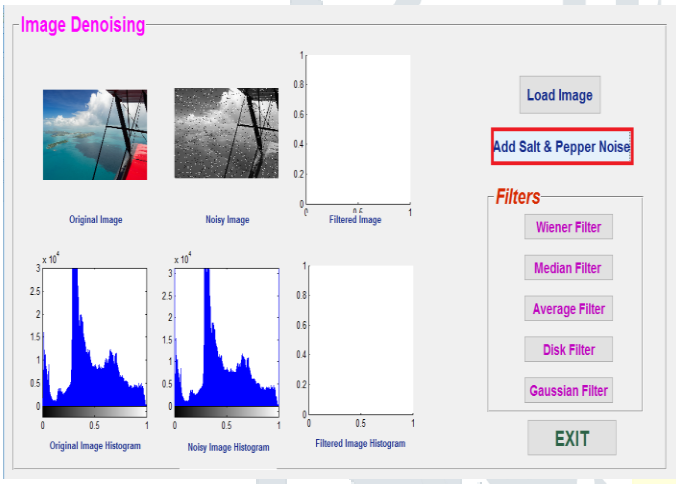


Figure 5: Add Salt & Pepper Noise to Image

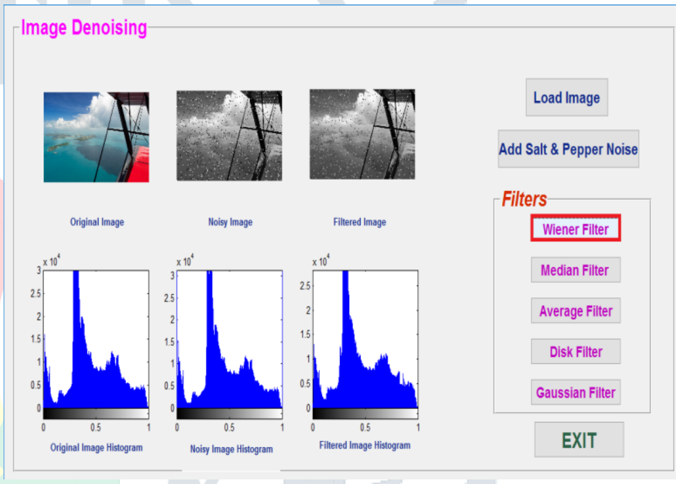
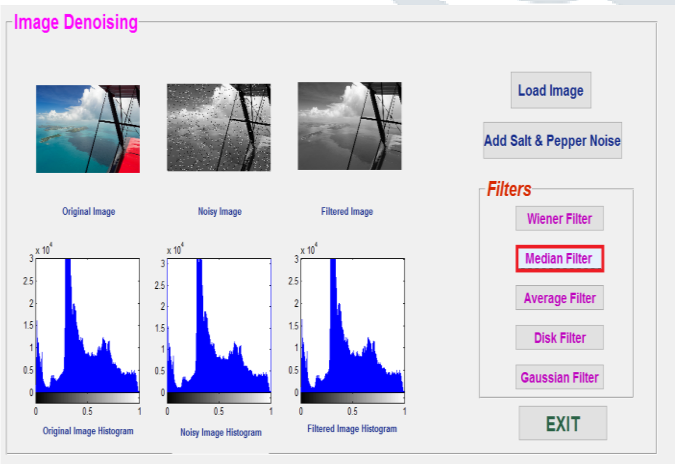
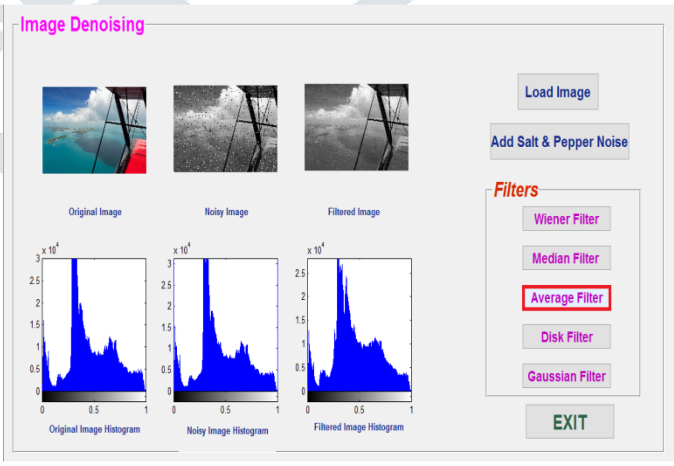


Figure 6: Image Denoising using Weiner Filter

Figure7 illustrates using Median filter to remove the noise. This filter provided the best result in removing the noise. Figures 8 and 9 illustrate using Average filter and Disk filter.





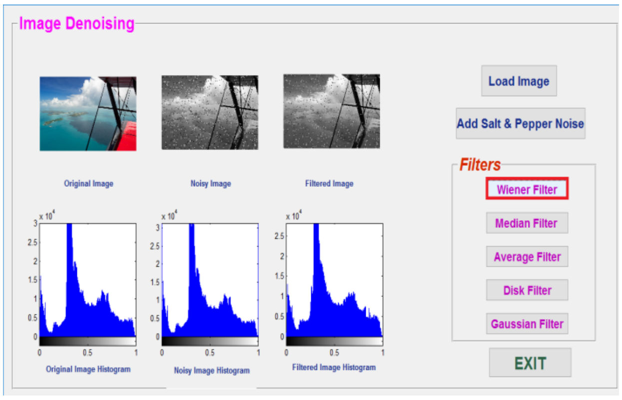


Figure 7: Image Denoising using Median Filter

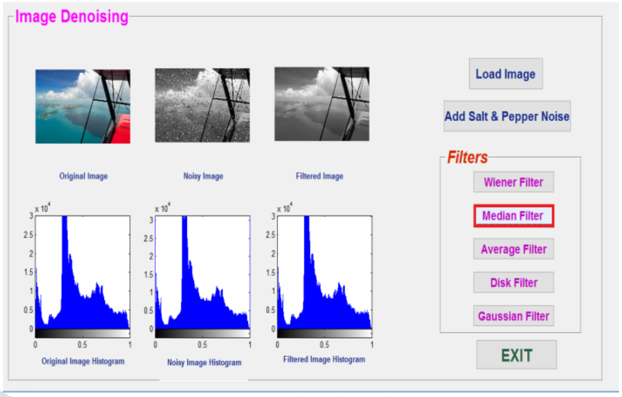


Figure 8: Image Denoising using Average Filter

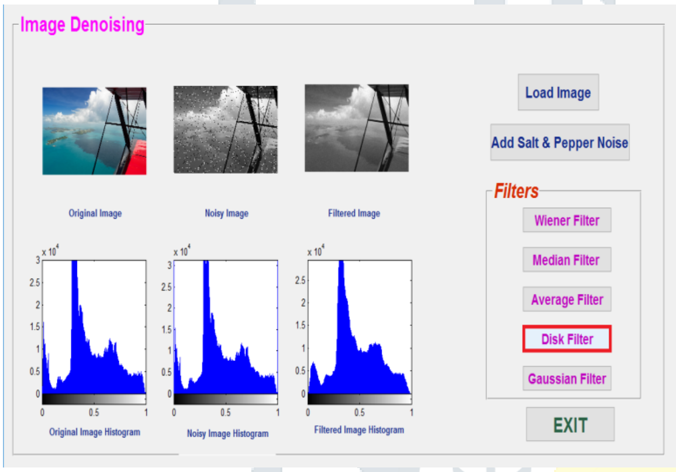


Figure 9: Image Denoising using Disk Filter

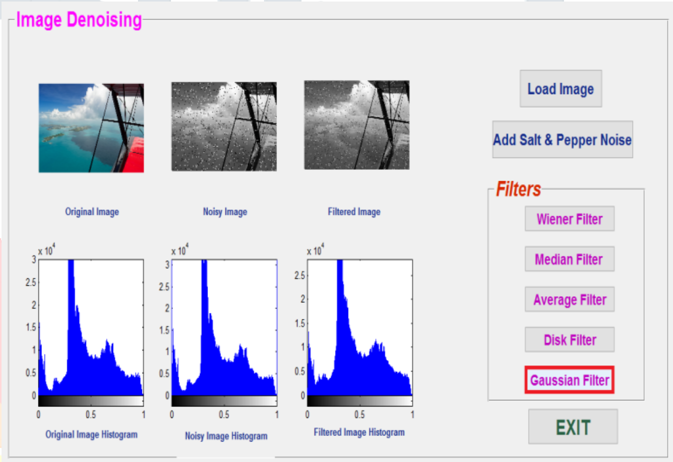


Figure 10: Image Denoising using Gaussian Filter

Figure 10 illustrates using Gaussian filter in removing noise. These filters are good for removing noise that is impulsive in nature.

V CONCLUSION

Images are very quick to respond to environmental effect. The main cause of these effects are thermal variation, fluctuation of quantum, orientation of image, image conversion etc. They produce noise and degrade the quality of image. Many of the current techniques assume the noise model to be Gaussian. In reality, this assumption may not always hold true due to the varied nature and sources of noise. An ideal denoising procedure requires a priori knowledge of the noise, whereas a practical procedure may not have the required information about the variance of the noise or the noise model. Denoising of images using the linear and nonlinear filtering techniques where linear filtering is done using the mean filter and the LMS adaptive filter while the nonlinear filtering is performed using a median filter. Our denoising algorithm performs the state-of-the art t denoising algorithms on real noise-contaminated images by generating shaper edges, producing smoother flat regions and preserving subtle texture details. Although all the spatial filters perform well on digital images but they have some constraints regarding resolution degradation. The contribution of this paper is course of action to smooth the noisy image with different kinds of denoising algorithms for desired edge preservation.

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