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Survey of Image Denoising using Different Filters

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Abstract— An image is considered as a collection of information and the occurrence of noises in the image causes degradation in the quality of the images. So the information associated with an image tends to loss or damage. It should be important to restore the image from noises for acquiring maximum information from images. In this paper we can see how different types of noise will affect the quality of the images and the information in images. As a remedy, the quality and the information from the noised image can be retrieved using different types of filters. In this work Gaussian noise, Salt and Pepper noise, Speckle noise and Poisson noise are being considered and it can be reduced using Gaussian filter, Wiener filter, Mean filter and Median filter. The experimental result shows the comparison and the performance of different types of filters to denoise the noised images from different types of noises with mean square errors and PSNR values.

Index Terms— Gaussian noise, Salt and Pepper noise, Mean filter, Median filter.

I. INTRODUCTION

Image denoising plays a vital role in digital image processing. 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 [1]. 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.

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II. WAVELET TRANSFORM

In digital image processing, Wavelet transform is very important tool for analyzing the image characteristics. For better analyzing purpose we transform the image from other domain to wavelet domain. In general there are many transforms are available like the Fourier transform, Wavelet transform and Hilbert transform. The Fourier transform is one of the most widely used and popular transform for analyzing purpose but it gives only the frequency amplitude representation not the time information. So it is not applicable to use the Fourier transform in applications which we need both time as well as frequency information at the same time. Fourier transform is one of the most powerful tools for processing the stationary signal (signal that as no change in the properties of signal) and it is not applicable for non-stationary signals (signal with there is change in the properties of signal). Wavelets allow filters to be constructed for Stationary and as well as non-stationary signals. So Wavelet transform is being preferred comparing to other transform. Wavelet transforms allow the both the components of stationary as well as non-stationary signal to be analyzed. Wavelet applications involves image signal processing and filtering. It also includes other area applications like non-linear regression and compression.

III. MEAN FILTER

There are two types of filtering schemes namely linear filtering and nonlinear filtering. [3] Mean filter comes under linear filtering scheme. Mean filter is also known as averaging filter. The Mean Filter applies mask over each pixel in the signal. Each of the components of the pixels comes under the mask are being averaged together to form a single pixel that's why the filter is otherwise known as average filter. Edge preserving criteria is poor in mean filter. Mean filter is defined by

$$\text{Mean filter} \quad (x_{1......}x_N) = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad (3.1)$$

Where (x_1 ….. x_N) is image pixel range. Mean filter is useful for removing grain noise from the photography image. As each pixel gets summed the average of the pixels in its neighborhood is found out, local variations caused by grain noise are reduced considerably by replacing it with average value.

IV. MEDIAN FILTER

[3]Median filter is the nonlinear filter. The main idea behind the median filter is to find the median value by across the window, replacing each entry in the window with the median value of the pixel.

123	125	126	130	140
122	**124**	**126**	**127**	135
118	**120**	**150**	**125**	134
119	**115**	**119**	**123**	133
111	116	110	120	130

Median value calculation

115,119,120,123, 124,125,126,127,150

Median value=124

[6]The pattern of neighbor's pixels is called the "window", when the window contains odd number of values in it then the median is simple: it is just the center value after all the entries in the window are sorted numerically in ascending order. But for an even number of entries, there is more than one center value; in that case the average of the two center pixel values is used. One of the major problems with the median filter is that it is relatively expensive and complex computation. For finding the median it is necessary to sort all the values in the neighborhood into numerical order and this filter relatively slow, even it is performed with fast sorting algorithms like quick sort. However the basic algorithm can be enhanced somewhat for the speed purpose.

V. WIENER FILTER

[5] The main aim of the Wiener filter is to filter out the image that has been corrupted by noise. Wiener filter is based on a statistical approach. Desired frequency response can be acquired using this filter. Approaches followed by wiener filtering are of different angle. For performing filtering operation it is must to have knowledge of the spectral properties of the original signal and the noise, in achieving the criteria one can get the LTI filter whose output will be as close as original signal as possible. Wiener filters possess characterized by the following:

a. Assumption: signal and (additive) noise are stationary linear random processes with known spectral characteristics.

b. Requirement: the filter must be causal where this requirement is failed it resulting in a non-causal solution

Periodic noise can be effectively removed by correcting the amplitude spectrum components altered by the noise, and two frequency filtering methods are currently available, i.e., Wiener filtering and notch filtering. However, a Wiener filter requires an accurate noise model, which may be difficult to obtain in various practical cases. In addition, a Wiener filter is also complicated in computation.

VI. GAUSSIAN FILTER

[2]The Gaussian filtering scheme is based on the peak detection. The peak detection is based on the fact that peaks are to be impulses. The key point is that this filter corrects not only the spectral coefficient of interest, but all the amplitude spectrum coefficients within the filter window.

Some properties of Gaussian filter are

1. The weights give higher significance to pixels near the edge (reduces edge blurring).

2. They are linear low pass filters.
3. Computationally efficient (large filters are implemented using small 1D filters).
4. Rotationally symmetric (perform the same in all directions).
5. The degree of smoothing is controlled by σ (larger σ for more intensive smoothing).

VII. IMAGE NOISE

Noise in images is caused by the random fluctuations in brightness or color information. Noise represents unwanted information which degrades the image quality. Noise is defined as a process which affects the acquired image quality that is being not a part of the original image content.

[2]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. In general image noise is regarded as an undesirable by-product of image capture.

The types of Noise are following:-

- Amplifier noise (Gaussian noise)
- Salt-and-pepper noise
- Shot noise (Poisson noise)
- Speckle noise

A. GAUSSIAN NOISE

[2]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. Gaussian noise is commonly defined as the noise with a Gaussian amplitude distribution, which states that nothing the correlation of the noise in time or the spectral density of noise. Gaussian noise is otherwise said as white noise which describes the correlation of noise. Gaussian noise is sometimes equated to be of white Gaussian noise, but it may not necessarily the case.

B.SALT AND PEPPER NOISE

In [2], [9], 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. In image criteria the noise itself represents as randomly occurring white and black pixels. 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.

C.POISSON NOISE

[2]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.

D.SPECKLE NOISE

In [2],[8],[10], 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. Due to random fluctuations in the return signal from an object in conventional radar that is not big as single image-processing element. Speckle noise occurs. Speckle noise increases the mean grey level of a local area. Speckle noise is more serious issue, causing difficulties for image interpretation in SAR images .It is mainly due to coherent processing of backscattered signals from multiple distributed targets.

VIII. SIMULATION RESULTS

Different image noise characteristics:

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(a)Original image

(b)Image with Salt and Pepper Noise

(c)Image with Gaussian noise

(d)Image with Poisson noise

(e)Image affected by speckle noise

Figure.1 Image affected by different types of noise

Fig.1. (a) represents the original image being taken for our experimental purpose. Fig 1(b) represents the image being affected by Salt and Pepper noise. Salt and pepper noise is typically seen in this image. The typical intensity value for pepper noise is close to 0 and for salt noise is close to 255 It represents itself as randomly occurring white and black pixels.Fig1(c) represents the image affected by Gaussian noise. Here we can observe that noise can take here are Gaussian-distributed. Fig.1 (d) represents the image affected by Poisson noise and Fig 1(e) represents the image being affected by speckle noise.

As we see from above results Noise in images causes degradation in image quality. So the information associated with the images is damaged as we said earlier. It is must to restore the image from noises for acquiring maximum information from images. As a remedy, the quality and the information from the noised image can be retrieved using different types of filters.

(a) Salt and Pepper noised image is filtered by Mean Filter

(b) Salt and Pepper noised image is filtered by Median Filter

(c) Salt and Pepper noised image is filtered by Wiener Filter

(d) Gaussian noised image filtered by Wiener Filter

(e) Gaussian noised image filtered by Mean Filter

(f) Gaussian noised image filtered by Median Filter

(g) Poisson noised image filtered by Wiener Filter

(h) Poisson noised image filtered by Mean Filter

(i) Poisson noised image filtered by Median Filter

(j) Speckle noised image filtered by Wiener Filter

(k) Speckle noised image filtered by Mean Filter

(l) Speckle noised image filtered by Median Filter

Figure 2 - Denoising using different filters

RESULTS ANALYSIS:

The performance analysis of different filter for different types of noises is quantized through Mean Square Error (MSE) value, Mean Absolute Error (MAE) and Peak to Signal Noise Ratio (PSNR) value.

Table 1: Median Filtering For Different Noise Types of Noises

Different noises	MSE	MAE	PSNR
Salt & pepper noise (10%)	30.2666	2.81	33.3212
Gaussian noise	304.0395	13.90	23.3015
Poisson noise	44.2809	4.96	31.6686
Speckle noise	215.7863	11.34	24.7863

From the results we obtained, it shows that the salt and pepper noise affected image is effectively denoised with median filter so we get low MSE and low MAE and high PSNR value compared to other filtered noise and median filter shows average removal of noise for Poisson noised image. But, when compared to salt and pepper and Poisson noise, Gaussian and speckle noise produces high MSE and MAE values. So it is observed that Median filter is not an appropriate filter for Gaussian and Speckle noise.

Table 2: Wiener Filtering for Different Types of Noises

Different noises	MSE	MAE	PSNR
Salt & pepper noise (10%)	372.7257	10.44	22.4169
Gaussian noise	159.8514	9.33	26.0936
Poisson noise	38.5027	4.43	32.2759
Speckle noise	125.8301	8.08	27.1330

The obtained results shows that the Poisson noise affected image is effectively denoised with Wiener filter so we get low MSE and low MAE and high PSNR value compared to other filtered noise and Wiener filter shows average removal of noise for Speckle and Gaussian noised image. But, when compared to Poisson noise, Salt and Pepper noise filtered image shows high MSE and MAE values. From this we conclude that wiener filter is not suitable for Salt and Pepper noised image.

IX. CONCLUSION

In this paper four types of noises (Salt and Pepper, Gaussian, Speckle and Poisson noise) had been added to the original clean 'Lena' image. We observed that all noise causes degradation in the image quality which results in loss of information. The denoising of degraded image is performed using Wiener, Mean and Median filter. From the simulation results its confirmed that Median filter works well for Salt and Pepper noise than Mean and Wiener filter whereas Wiener filter works well for removing Poisson and speckle noise compared to that of Mean and Median filter.

X. FUTURE WORK

Filtering methods along with detection algorithms shows better results and once the filtering schemes are done in wavelet domain then efficient results will be found.

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