PERFORMANCE ANALYSIS OF LINEAR AND NON LINEAR FILTERS FOR IMAGE DE NOISING

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ABSTRACT

An image is corrupted by different types of noises. Noise is any desired information that contaminates an image. Due to the presence of noise the information associated with the image can be damaged. Image de noising is the process to remove the noise while retaining as much as possible the important signal features. De noising can be done through both linear and nonlinear filtering techniques. In this paper the performance analysis of average filter, median filter, Gaussian filter, Alpha trimmed mean filter, Fuzzy logic based Alpha trimmed median filter is analyzed. The distinctive feature of the all the proposed filters is that it offers well line, edge, detail and texture preservation performance while, at the same time, effectively removing noise from the input images. Here the Gaussian noise, salt and pepper noise, speckle noise, Poisson noise are added to the images and then linear and nonlinear filtering techniques are applied to the noisy images to remove the noise. The performance of the filters is compared using PSNR, MSE. The experimental results show the comparison and the better filtering techniques for the purpose of noise removal.

Keywords: *De noising, average, median, Gaussian Alpha trimmed mean filter, salt and pepper, speckle and Poisson noise, PSNR, MSE.*

1. INTRODUCTION

Image de noising plays an important role in digital image processing. There are many schemes for removing noise from images. The good de noising 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 de noising techniques, linear and nonlinear techniques. The goal of the filtering action is to cancel noise while preserving the integrity of edge and detail information, nonlinear approaches generally provide more satisfactory results than linear techniques.

1. FILTERING TECHNIQUES

There are two types of filtering techniques:

1.1 Linear filtering techniques

Linear filtering can improve images in many ways: sharpening the edges of objects, reducing random noise, correcting for unequal illumination, deconvolution to correct for blur and motion, etc. The main benefits of using linear filtering is the speed. Some of the linear filtering techniques are:

- ➢ Average filter
- ➢ Gaussian filter

Average filter

The average filter comes under the linear filtering scheme. Averaging filter is also known as Mean filter. The Mean filter 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 the pixels come under the mask are being averaged together to form a single pixel so the filter is otherwise known as average filter. Edge preserving criteria are poor in mean filter. Mean filter is defined by

$$(x(1)\ldots\ldots x(n)) \quad = 1/n \sum_{i=1}^{n} x(i)$$

Gaussian filter

The Gaussian filtering technique is a linear filter technique is based on the peak detection. The peak detection is based on the fact that the peaks are to be impulses. The filter corrects not only the spectral coefficient of interest, but all the amplitude spectrum coefficients within the filter window.

Some properties of Gaussian filter area

1. The weights give higher significance   to pixels near the edge.

2. They are linear low pass filters.

3. Computationally efficient.

4. Rotationally symmetric.

1.2 Nonlinear filtering techniques

Non-linear techniques do not explicitly implement the inverse; instead it uses an iterative approach to produce restoration until a termination condition is reached. Non-linear models can preserve edges in a much better way than linear models but very slow. Some of the nonlinear filtering techniques are:

- ➢ Median filter
- ➢ Alpha trimmed mean filter
- ➢ Fuzzy logic based alpha trimmed median filter.

Median filter

Median filter is the nonlinear filter. 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.

11	98	45	34	19
25	**34**	**27**	**85**	30
51	**55**	**67**	**41**	74
45	**32**	**70**	**58**	68
29	13	66	91	59

The median value calculation is
27, 32, 34, 41, 55, 58, 67, 70, 85
Median value = 55

When the window contains an odd number of values in it than the median is simple: it is just the center value after all the entries in the windows 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.

Alpha trimmed mean filter

The filter is a windowed filter of nonlinear class. It is hybrid of mean and median filter. The idea behind the filter is for any element of the signal look at its neighborhood, discard the most typical elements and calculate mean value using rest of them. The extreme minimum and maximum value of the windowed pixel will affect the average values calculated. Trimming the pixels from both min and max extremes the optimum performance can be achieved. R factor is used to quantify the number of pixels to be trimmed from the min extreme. S factor is used to quantify the number of pixels to be trimmed from the min and max extreme. Alpha trimmed mean filter is:

$$y_n(i\,;\alpha) = \frac{1}{n-2[\alpha n]} \; \sum_{j=[\alpha n]+1}^{n-[\alpha n]} x\,(i)$$

Fuzzy logic based alpha trimmed median filter

The general idea behind the fuzzy filter is to average a pixel value from its neighborhood, but simultaneously take care of important image structures such as edges. Arranging the pixels in orders and the middle value is chosen. The corrupted pixels are replaced by middle value using the order statistic filter. The computation of optimized weights of pixels is formulated using membership functions. Finally, using the median filter remaining pixels containing noises are removed. The alpha trimmed median filter is:

$$f(x,y) = \frac{1}{mn-d} \sum_{(s,t)£S} g(s,t)$$

➢ Delete d/2 lowest and d/2 highest value of g (s, t)
➢ g (s, t) remains
➢ d=0 arithmetic mean filter
➢ d = mn-1 median filter

Algorithm

Step 1: Read the input image.

Step 2: Adding noise to the input image and create fuzzy logic based Mamdani network.

Step 3: Fuzzy membership function is defined i.e. F (i, j)

Step 4: Restoring term for detecting noise pixel is computed at the edges using fuzzy rules.

Step 5: Delete the d/2 largest and d/2 smallest grayscale values

Step 6: Take the median for rest of grayscale values and update the median filter for every row and columns.

Step 7: Reconstruct the de noised image

3. 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. Digital image noise may occur due to various sources. Some of the image noise are as follows

➢ Gaussian noise
➢ Salt and pepper noise
➢ Poisson noise
➢ Speckle 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, the values of that the noise is being Gaussian-distributed. A special case of Gaussian noise is white Gaussian noise, in which the values always are statistically independent. For application purposes, 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 in the correlation of the noise in time or the spectral density of the 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. 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 the images. In image criteria the noise itself represents as randomly occurring white and black pixels. Salt and pepper noise occurs in images under situations where quick transients, such as faulty switching take place.

Poisson noise

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

Speckle noise

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 images. Due to random fluctuations in the return signal from an object on conventional radar that is not big as single image-processing element. Speckle noise increases the mean gray level of a local area.

4. EXPERIMENTAL RESULTS

Different image noises are represented in Fig.1. The original image being taken for image de noising is Fig.1. (a). Different noises such as salt and pepper noise, Gaussian noise, Poisson noise, speckle noise is represented in Fig.1. (b) To Fig.1. (e). Salt and pepper noise is added to the original image at 10%. Gaussian noise image here taken is Gaussian distributed. From these below figures the noise affects the image quality. So the information in the images is damaged and the noise also affects the image quality. For this difficulty different types of De noising filters are used to remove the noises and improve the edges sharpness. The filters are designed to improve the image quality.

(a) Original image   (b) salt and pepper noise   (c) Gaussian noise   (d) Poisson noise

(e) Speckle noise

Figure.1 Image affected by different types of noises

(a) De noised image from salt and pepper, Gaussian, Poisson, speckle noise using a mean filter

(b) De noised image from salt and pepper, Gaussian, Poisson, speckle noise using median filter

(c) De noised image from salt and pepper, Gaussian, Poisson, speckle noise using Gaussian filter

(d) De noised image from salt and pepper, Gaussian, Poisson, speckle noise using Alpha trimmed mean filter

(e) De noised image from salt and pepper, Gaussian, Poisson, speckle noise using fuzzy logic based Alpha trimmed median filter

Figure.2 Noise removed using Different de noising filters

The above figures represent the different de noising filtering techniques. Fig.2. (a) Represent the de noising the noisy images using an average filter. Fig.2. (b) Represent the de noising the noisy images using median filter. Fig.2. (c) Represent the de noising the noisy image using Gaussian filter. Fig.2. (e) Represent the de noising the noisy images using Alpha trimmed mean filter. Fig.2. (e) Represent the de noising the noisy images using fuzzy logic based Alpha trimmed median filter. Both the linear and nonlinear filtering techniques are used.

5. RESULT ANALYSIS

Table.1 Comparison of filters using Mean square error (MAE) and Peak signal to noise ratio (PSNR)

METHOD	MSE	PSNR	NOISE TYPE
Mean Filter	1.1280e+03	17.6077	Salt and pepper (10%)
	1.2510e+03	17.1582	Gaussian
	1.1313e+03	17.5950	Poisson
	1.1152e+03	17.6574	Speckle
Median Filter	234.8655	24.4226	Salt and pepper (10%)
	725.7281	19.5231	Gaussian
	259.0065	23.9977	Poisson
	350.3163	22.6852	Speckle
Gaussian Filter	259.6335	23.9872	Salt and pepper (10%)
	564.7429	20.6123	Gaussian
	194.0455	25.2518	Poisson
	174.5177	25.7124	Speckle
Alpha Trimmed Mean Filter	0.0154	18.1361	Salt and pepper (10%)
	0.0158	18.0148	Gaussian
	0.0153	18.1449	Poisson
	0.0160	17.9541	Speckle
Fuzzy Logic Based Alpha Trimmed Median Filter	4.6357e-04	33.3388	Salt and pepper (10%)
	0.0074	21.2815	Gaussian
	4.2866e-04	33.6789	Poisson
	0.0014	28.5589	Speckle

Table.1. Represents the comparison of filters using the mean square error (MAE) and peak signal to noise ratio (PSNR)

PSNR and MSE are calculated for all the linear and nonlinear filters. By using these values, we can identify the quality of the image. The first MSE value is calculated it's important for PSNR value. The table shows better filtering technique to remove the noises from the images. The Fuzzy logic based alpha trimmed median filter has the high PSNR value when compare with other filters for all the noises. Fuzzy logic based alpha trimmed median filter is considered as the better filter technique to remove the noise.

6. CONCLUSION

In this paper linear and nonlinear filtering techniques are used to remove the different types of noises in the original image. All the noises affect the image quality and also causes the degradation. From the simulation results nonlinear filter called fuzzy logic based Alpha trimmed median filter has the high PSNR value for all the noises. It preserves the sharpness of the edges while removing the noises. From the simulation results it's confirmed that nonlinear filter techniques give the better performance when compared with linear filtering techniques in terms of PSNR and MSE.

7. FUTURE WORK

Filtering techniques are done with in wavelet domain give the better results. Different filtering techniques are used for improving the quality of images and also for preserving the edges.

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