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IMAGE DE-NOISING USING WAVELET TRANSFORM AND VARIOUS FILTERS

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Abstract *: The process of removing noise from the original image is still a demanding problem for researchers. There have been several algorithms and each has its assumptions, merits, and demerits. The prime focus of this paper is related to the pre processing of an image before it can be used in applications. The pre processing is done by de-noising of images. In order to achieve these de-noising algorithms, filtering approach and wavelet based approach are used and performs their comparative study. Different noises such as Gaussian noise, salt and pepper noise, speckle noise are used. The filtering approach has been proved to be the best when the image is corrupted with salt and pepper noise. The wavelet based approach has been proved to be the best in de-noising images corrupted with Gaussian noise. A quantitative measure of comparison is provided by the parameters like Peak signal to noise ratio, Root mean square error and Correlation of the image.*

Keywords: *Gaussian noise, Salt & Pepper noise, Speckle noise, Average filter, Wiener filter, Gaussian Filter.*

I. INTRODUCTION

An image is a two dimensional function f(x, y), where x and y are plane coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the gray level or intensity of the image at that point. Digital images consist of a finite number of elements where each element has a particular location and value. These elements are called picture elements, image elements and pixels. There are two types of images i.e. grayscale image and RGB image. Gray scale image has one channel and RGB image has three channels i.e. red, green and blue. Image noise is unwanted fluctuations.There are various types of image noises present in the image like gaussian noise, salt & pepper noise, speckle noise, shot noise, white noise[1]. There are various noise reduction techniques which are used for removing the noise. Most of the standard algorithms use to de-noise the noisy image and perform the individual filtering process. The result is that it generally reduces the noise level. But the image is either blurred or over smoothed due to losses like edges or lines. Noise reduction is used to remove the noise without losing much detail contained in an image[2]. To achieve this goal, we use the mathematical function known as the wavelet transform to localize an image into different frequency components or useful sub-bands and effectively reduce the noise in the sub-bands into different frequency components or useful sub-bands and effectively reduces the noise in the sub-bands.

II. GAUSSIAN FILTER

Gaussian filters are designed to give no overshoot to a step function input while minimizing the rise and fall time. This behavior of Gaussian filter causes minimum group delay. Mathematically, a Gaussian filter modifies the input signal by convolving with a Gaussian function. The Gaussian filter is usually used as a smoother. The output of the Gaussian filter at the moment is the mean of the input values [3].

III. WIENER FILTER

It is used to reduce disturbance (noise) present in a signal by comparison with an estimation of the desired noiseless signal. The design of the Wiener filter is of different approach. The Wiener filtering is a linear estimation of the original image [4]. The approach is based on a stochastic framework. Wiener filters are characterized by the following:

1. Assumption: signal and (additive) noise are stationary linear with known spectral characteristics
2. Requirement: the filter must be physically realizable/causal system.
3. Performance criterion: minimum MMSE[5]

IV. AVERAGE FILTER

Mean filter, or average filter is windowed filter of linear class, that smoothes signal (image). The filter works as low-pass one. The basic idea behind filter is for any element of the signal (image) take an average across its neighbourhood. To understand how that is made in practice, let us start with window idea.The Average (mean) filter smooths image data, thus eliminating noise [6]. This filter performs spatial filtering on each individual pixel in an image using the grey level values in a square or rectangular window surrounding each pixel[5].

For example:

a1	a2	a3	
a4	a5	a6	3x3 filter window
a7	a8	a9	

The average filter computes the sum of all pixels in the filter window and then divides the sum by the number of pixels in the filter window:

Filtered pixel = (a1 + a2 + a3 + a4 ... + a9) / 9

V. IMAGE NOISE

The sources of noise in digital images arise during image acquisition and/or transmission with unavoidable shot noise of an ideal photon detector [10]. The performance of imaging sensors are affected by a variety of factors during acquisition, such as

- Environmental conditions during the acquisition
- Light levels (low light conditions require high gain amplification).
- Sensor temperature (higher temp implies more amplification noise)

Depending on the specific noise source, there are different types of noises

- Gaussian noise
- Salt-and-pepper noise
- Speckle noise

A. Gaussian Noise

Gaussian nois**e** is a noise that has its PDF equal to that of the normal distribution, which is also known as the Gaussian distribution. Gaussian noise is most commonly known as additive white Gaussian noise. Gaussian noise is properly defined as the noise with a Gaussian amplitude distribution. Labeling Gaussian noise as 'white' describes the correlation of the noise. It is necessary to use the term "white Gaussian noise" to be precise[7][15].

B. Salt-and-Pepper Noise

Salt and pepper noise is a noise seen on images. It represents itself as randomly occurring white and black dots. An effective filter for this type of noise involves the usage of a median filter. Salt and pepper noise creeps into images in situations where quick transients, such as faulty switching, take place[9].

C. Speckle Noise

Speckle noise is caused by signals from elementary scatterers, the gravity-capillary ripples, and manifests as a pedestal image.Several different methods are used to eliminate speckle noise, based upon different mathematical models of the phenomenon. One method, for example, employs multiple-look processing[14][16]. A second method involves using adaptive and non-adaptive filters on the signal processing. Such filtering also eliminates actual image information as well, in particular high-frequency information, whereas the applicability of filtering and the choice of filter type involves tradeoffs. Adaptive speckle filtering is better at preserving edges and detail in high-texture areas (such as forests or urban areas)[8][22]. Non-adaptive filtering is simpler to implement, and requires less computational power.There are two forms of non-adaptive speckle filtering: one based on the mean and other based upon the median (within a given rectangular area of pixels in the image). The latter is better at preserving edges whilst eliminating noise spikes, than the former is[11].

VI. WAVELET TRANSFORM

Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. They have advantages over traditional Fourier methods in analyzing physical situations where the signal contains discontinuities and sharp spikes[20]. Wavelets were developed independently in the fields of mathematics, quantum physics, electrical engineering, and seismic geology. Interchanges between these fields during the last ten years have led to many new wavelet applications such as image compression, turbulence, human vision, radar, and earthquake prediction[12][18]. A wavelet transform is the representation of a function by wavelets. The wavelets are scaled and translated copies of a mother wavelet. Wavelet analysis represents the next logical step: a windowing technique with variable-sized regions. Wavelet analysis allows the use of long time intervals where we want more precise low-frequency information, and shorter regions where we want high frequency information.Wavelet transforms are classified into discrete wavelet transforms (DWTs) and continuous wavelet transforms (CWTs). Both DWT and CWT are continuous-time (analog) transforms. They can be used to represent continuous-time (analog) signals. CWTs operate over every possible scale and translation whereas DWTs use a specific subset of scale and translation values or representation grid[13].

VII. PARAMETRIC DESCRIPTION

A. Algorithm for Peak Signal to Noise ratio (PSNR)

Step1: Difference of noisy image and noiseless image is calculated using imsubract Command.

Step2: Size of the matrix obtains in step 1 is calculated.

Step3: Each of the pixels in the matrix obtained in step is squared.

Step4: Sum of all the pixels in the matrix obtained in Step3 is calculated.

Step5: (MSE) is obtained by taking the ratio of value obtained in step 4 to the value obtained in the Step2

Step6: (RMSE) is calculated by taking square root to the value obtained in Step5.

Step7: Dividing 255 with RMSE, taking 1og base 10 and multiplying with 20 gives the value of PSNR.

B. Algorithm for Correlation of Coefficient (Coc)

Step1: Mean of the noiseless image and noisy image are calculated.

Step2: Mean of the noiseless image is subtracted from each of the pixel in the noiseless image resulting in a matrix.

Step3: Similarly the mean of noisy image is subtracted from each of the pixels in the noise image resulting in a matrix.

Step4: Values obtained in Step2 and Step3 are multiplied.

Step5: Sum of all the elements in the matrix obtained in Step4 is calculated.

Step6: Square of all the elements of the matrix obtained in Step2 is calculated and sum of this squared matrix is determined.

Step7: Similarly square of all the elements of the matrix obtained in Step3 is calculated and sum of the elements of this squared matrix is also determined.

Step8: Values obtained in Step6 and Step7 are multiplied and its square root is taken.

Step9: Ratio of the value obtained in Step5 to the value obtained in Step8 is calculated.

C. Algorithm for Root Mean Square Error (RMSE)

Step1: Difference of noisy image and noiseless image is calculated using *imsubract* command.

Step2: Size of the matrix obtains in Step1 is calculated.

Step3: Each of the pixels in the matrix obtained in step is squared.

Step4: Sum of all the pixels in the matrix obtained in step 3 is *calculated.*

Step5: (MSE) is obtained by taking the ratio of value obtained in Step4 to the value obtained in the step 2.

Step6: (RMSE) is calculated by taking square root to the *value* obtained in Step5.

D. Algorithm for filter selection

Step1: Noiseless image are given as input.

Step2: Noisy image are then given as input.

Step3: Noisy image is filtered by all the filters i.e. Gaussian, average, wiener and wavelet filter with respect to the noiseless image.

Step4: The statistical parameters are calculated for the filtered image obtained from filtering

Step5: Finally we get sets of statistical parameters each set corresponding to 1 filter.

VIII. SIMULATION RESULTS

The original image is Lena image, adding three types of noise (Gaussian noise, Speckle noise and Salt & Pepper noise) and De-noised image using Average filter, Gaussian filter and Wiener filter and Wavelet domain and comparison among them.

Figure 1: Original Lena image taken as reference

Figure 2: Noisy image: Gaussian noise with mean and variance = 0.005

Figure 3: Noisy image: Speckle noise with variance = 0.005

Figure 4: Noisy image: Salt & pepper noise with noise density = 0.003

Figure 5: .De-noising by Gaussian Filter for Gaussian noise with mean and variance=0.005

Figure 6: De-noising by Average Filter for Gaussian noise with mean and variance=0.005

Figure 7: De-noising by Wiener Filter for Gaussian noise with mean and variance=0.005

Figure 8: De-noising by Wavelet Transform for Gaussian noise with mean and variance=0.005

Figure 9: De-noising by Gaussian Filter for Speckle noise with variance=0.005

Figure 10: De-noising by Average Filter for Speckle noise with variance=0.005

Figure 11: De-noising by Wiener Filter for Speckle noise with variance=0.005

Figure 12: De-noising by Wavelet Transform for Speckle noise with variance=0.005

Figure 13: De-noising by Wiener Filter for Salt & Pepper noise with noise density=0.003

Figure 14: De-noising by Average Filter for Salt & Pepper noise with noise density=0.003

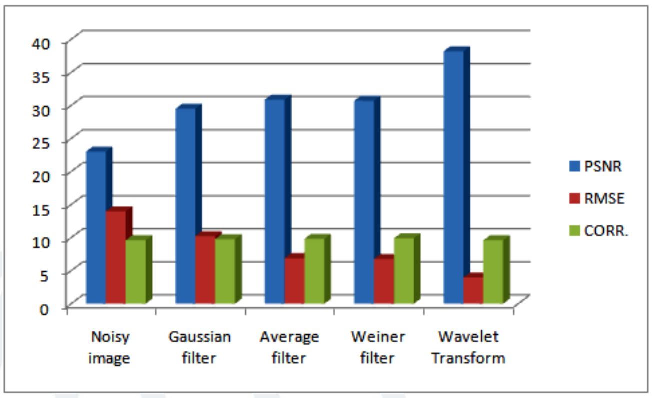
Figure 15: De-noising by Gaussian Filter for Salt & Pepper noise with noise density=0.003

Figure 16: De-noising by Wavelet Transform for Salt & Pepper noise with noise density=0.003

IX. RESULTS

Table 1: Gaussian noise with mean = 0.005 and variance=0.005

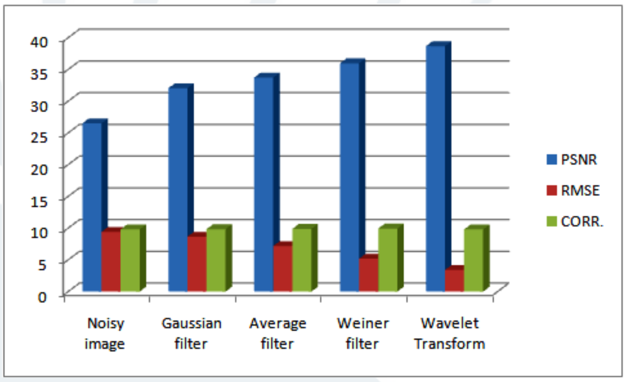
	PSNR	RMSE	CORR.
Noisy image	23.0175	13.9845	9.599
Gaussian filter	29.4960	10.2269	9.77
Average filter	30.8939	6.88995	9.828
Weiner filter	30.7065	6.7678	9.90
Wavelet Transform	38.1974	3.9845	9.599



This graph shows the Wavelet Transform is more effective than Gaussian filter, Average filter and Wiener filter to remove the Gaussian noise.

Table 2: Speckle noise with variance=0.005

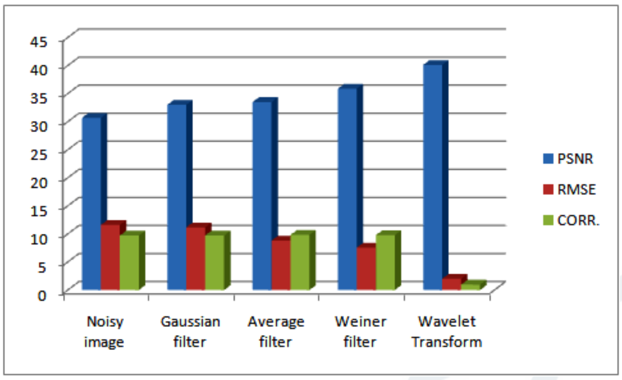
	PSNR	RMSE	CORR.
Noisy image	26.5260	9.4079	9.812
Gaussian filter	32.0440	8.6517	9.838
Average filter	33.728	7.1806	9.89
Weiner filter	35.9795	5.1934	9.94
Wavelet Transform	38.6750	3.4079	9.8



This graph shows the Wavelet Transform is more effective than Gaussian filter, Average filter and Wiener filter to remove the Gaussian noise.

Table 3: Salt & Pepper noise with noise density= 0.003

	PSNR	RMSE	CORR.
Noisy image	30.6851	11.6063	9.715
Gaussian filter	33.0065	11.172	9.73
Average filter	33.5021	8.8067	9.833
Weiner filter	35.8945	7.5666	9.78
Wavelet Transform	40.1194	2.0111	0.97



This graph shows the Wavelet Transform is more effective than Gaussian filter, Average filter and Wiener filter to remove the Gaussian noise.

Table 4: Performance analysis of Average, Wiener, Gaussian filter and Wavelet Transform for different noise

Filter Name	De-noising Result for Gaussian noise	De-noising Result for Speckle noise	De-noising Result for Salt & Pepper noise
Gaussian filter	70%	70%	70%
Average filter	80%	75%	72%
Weiner filter	80%	90%	80%
Wavelet Transform	95%	95%	96%

X. CONCLUSION

We used the Lena Image (figure 1) in “jpg” format, adding three noise (Speckle, Gaussian and Salt & Pepper).In these image (figure 2 to figure 4), De-noised all noisy images by all Filters and Wavelet Transform and conclude from the results (figure 5 to figure 16) that: The performance of the Wavelet domain is better than Wiener filter, Gaussian filter and Average Filter.

XI. REFERENCES

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