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Analysis of Noise Removal Filtering Techniques

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ABSTRACT: This paper represents the de-noising strategies comparison for lena picture, whose image qualities area unit degraded by totally different variety of noise enclosed. The strategies area unit diagrammatical in sequence on the idea of concerning analysis on the subject, and consist in ripple primarily based linear filtering of the image, admire vertical and diagonal parameters. A comparison with another filtering technique for lena picture, i.e. wiener and median filter, is additionally conferred. The ultimate results combined with different reportable in freelance analysis, demonstrate that the ripple primarily based linear de-noising technique has higher performance and area unit terribly promising for image processing applications.

KEYWORDS: Wavelet Transform, Weiner filter, Median filter, PSNR, Gaussian noise.

I. Introduction

In the method of image acquisition and transmission, noise is often contained inevitably. Thus it's necessary to image denoising process to boost the standard of image. Abundant sensible noise will be approximated as noise with Gauss distribution, and removal of superposition of Gauss noise has become a vital direction in image denoising analysis. Usually speaking, every algorithmic program has some filtering and threshold parameters. Taking selection varieties of pictures into consideration, it's a key downside of the way to set these parameters in denoising algorithms underneath totally different conditions to attain higher performance.

Simple linear smoothing filter, like Gauss filter [1-3], can cause the detail info loss of image. In recent years, an oversized variety of complicated denoising algorithms mean of nonlinear filter has appeared. Common algorithmic programs embody a range of reconciling median filter algorithms: the rippling threshold [4-8] (also known as rippling shrinkage) algorithm, the aeolotropic diffusion equation algorithmic program [9-12], the full variation step-down algorithmic program [13-16], non-local mean filter algorithmic program [17-20], etc.

Filtering is probably the foremost elementary operation of image process and pc vision. Within the broadest sense of the term "filtering," the worth of the filtered image at a given location may be perform of the values of the input image in an exceedingly tiny neighborhood of constant location. Particularly, mathematician low-pass filtering computes a weighted average of picture element values within the neighborhood, in which, the weights decrease with distance from the neighborhood center.

Although formal and quantitative explanations of this weight fall-off will be given [11], the intuition is that pictures generally vary slowly over area, thus close to pixels are seemingly to possess similar values, and it's so applicable to average them along. The noise values that corrupt these close pixels are reciprocally less related than the signal values, thus noise is averaged away whereas signal is preserved.

II. Image De-noising Methods

There are two domains of image types filtering: Spatial filtering and transform domain filtering.

A. *Spatial Domain Filtering*

Median Filter

The median filter may be a fashionable nonlinear digital filtering technique, usually accustomed take away noise. Such noise reduction may be a typical pre-processing step to boost the results of later process (for example, edge detection on associate degree image). Median filtering is extremely wide utilized in digital image process as a result of below bound conditions, it preserves edges whereas removing noise [21].

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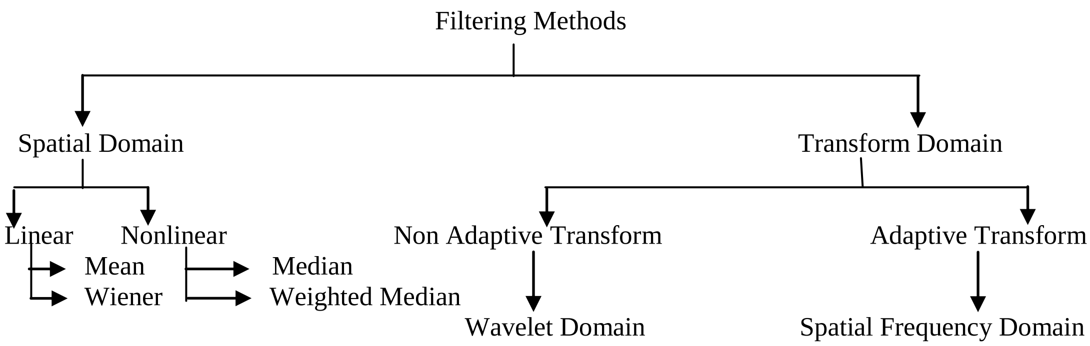

Generally called a rank filter, this spatial filter suppresses isolated noise by replacement every pixel's intensity by the median of the intensities of the pixels in its neighbourhood. It's wide utilized in de-noising and image smoothing applications. Median filters exhibit edge-preserving characteristics (cf. linear strategies like average filtering tends to blur edges), that is extremely fascinating for several image process applications as edges contain necessary data for segmenting, labelling and conserving detail in pictures. This filter is also drawn by equivalent weight eq.1.

$$T(a,b) = median\{I(x,y),(x,y)\epsilon wF\} \qquad \text{eq. 1}$$

where $wF = w\ x\ w$ Filter window with pixel (a,b) as its middle

Wiener filter

Wiener filters are a category of optimum linear filters that involve linear estimation of a desired signal sequence from another connected sequence. It's not associate degree adaptive filter. The wiener filter's main purpose is to scale back the number of noise gift in a picture by comparison with associate degree estimation of the specified quiet image. The Wiener filter may additionally be used for smoothing. This filter is that the mean squares error-optimal stationary linear filter for pictures degraded by additive noise and blurring. It's typically applied within the frequency domain (by taking the Fourier transform) [23], thanks to linear motion or unfocussed optics Wiener filter is that the most significant technique for removal of blur in pictures. From a sign process stance. Every pel in a very digital illustration of the photograph ought to represent the intensity of one stationary purpose before of the camera. Sadly, if the shutter speed is just too slow and also the camera is in motion, a given pel are associate degree amalgram of intensities from points on the road of the camera's motion.

The goal of the Wiener filter is to strain noise that has corrupted a sign. It's supported an applied math approach. Typical filters are designed for a desired frequency response. The Wiener filter approaches filtering from a special angle. One is assumed to own data of the spectral properties of the first signal and also the noise, and one seeks the LTI filter whose output would come back as near the first signal as potential [22]. Wiener filters are characterized by the following:

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

(b) Requirement: the filter should be physically realizable, i.e. causative (this demand may be born, leading to a non-causal solution).

(c) Performance criteria: minimum mean-square error.

Wiener Filter in the Fourier Domain as in eq. 2.

$$G(u,v) = \frac{H^*(u,v)P_s(u,v)}{|H(u,v)|^2 P_s(u,v) + P_n(u,v)} \qquad \text{eq. 2}$$

Where

(u,v) = Fourier transform of the point spread function

(u,v) = Power spectrum of the signal process, obtained by taking the Fourier transform of the signal autocorrelation

(u,v) = Power spectrum of the noise process, obtained by taking the Fourier transform of the noise autocorrelation

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B. *Transform Domain Filtering*

The transform domain filtering methods can be subdivided according to the choice of the basic functions. The basic functions can be further classified as data adaptive and non-adaptive. Non-adaptive transforms are discussed first since they are more popular.

Spatial-Frequency Filtering

Spatial-frequency filtering refers use of low pass filters victimization quick Fourier rework (FFT). In frequency smoothing strategies [24] the removal of the noise is achieved by planning a frequency domain filter and adapting a cut-off frequency once the noise elements are decorrelated from the helpful signal within the frequency domain. These strategies are time intense and rely upon the cut-off frequency and therefore the filter perform behavior. Moreover, they will turn out artificial frequencies within the processed image.

Wavelet domain

Filtering operations within the riffle domain is divided into linear and nonlinear ways.

Linear filters like Wiener filter within the riffle domain yield optimum results once the signal corruption is shapely as a mathematician method and also the accuracy criterion is that the mean sq. error (MSE) [25, 26]. However, planning a filter supported this assumption oftentimes leads to a filtered image that's a lot of visually off-putting than the first signal, even supposing the filtering operation with success reduces the MSE. In [27] a wavelet-domain spatially accommodative FIR Wiener filtering for image denoising is planned wherever wiener filtering is performed solely at intervals every scale and intrascale filtering isn't allowed.

The most investigated domain in denoising victimization riffle remodel is that the non-linear constant thresholding primarily based ways. The procedure exploits sparseness property of the riffle remodel and also the undeniable fact that the riffle remodel maps dissonance within the signal domain to dissonance within the remodel domain. Thus, whereas signal energy becomes a lot of targeted into fewer coefficients within the remodel domain, noise energy doesn't. It's this vital principle that permits the separation of signal from noise. The procedure within which little coefficients are removed whereas others are left untouched is termed arduous Thresholding [28]. However the strategy generates spurious blips, higher referred to as artifacts, within the pictures as a results of unsuccessful tries of removing moderately massive noise coefficients. To beat the demerits of arduous thresholding, riffle remodel victimization soft thresholding was additionally introduced in [28]. During this theme, coefficients higher than the brink are shrunken by absolutely the price of the brink itself. Almost like soft thresholding, different techniques of applying thresholds are semi-soft thresholding and Garrote thresholding [29]. Most of the riffle shrinkage literature is predicated on ways for selecting the optimum threshold which may be accommodative or non-adaptive to the image.

III. ALGORITHM OF PROPOSED SYSTEM

Algorithm of proposed wavelet based linear filter is described stepwise:

Step1: Read input image.

Step2: Convert RGB to gray if required.

Step3: Calculate image matrix size.

Step4: Generate Noise signal of same size and add to original signal

Step5: Applying wavelet based linear filter.

Step6: Reconstruct original signal

IV. SIMULATION RESULTS: COMPARISON OF FILTERS

Different types of filters are compared in terms of power of signal to noise ratio of signal on matlab software. To compare performance of filters lena image is considered and Gaussian noise is added to Lena image. Lena image is shown in figure 1(a). Firstly Gaussian noise of same size as Lena image is generated with zero mean value is added to signal and shown in figure 1(b).

To calculate PSNR value, first we need to calculate mean square error. MSE can be calculated as

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \qquad \text{eq. 3}$$

The *PSNR* is defined by eq. 4

$$PSNR_{db} = 10log_{10}\left(\frac{MAX_I^{\ 2}}{MSE}\right) \qquad \text{eq. 4}$$

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Where MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, which is equal to 255.
For wavelet based linear transform parameters are taken as spatial sigma 1.5, multiplication factor 4, kernel size 11, Number of levels 3, Wavelet name db8, thresholding type soft, and noise type Gaussian.

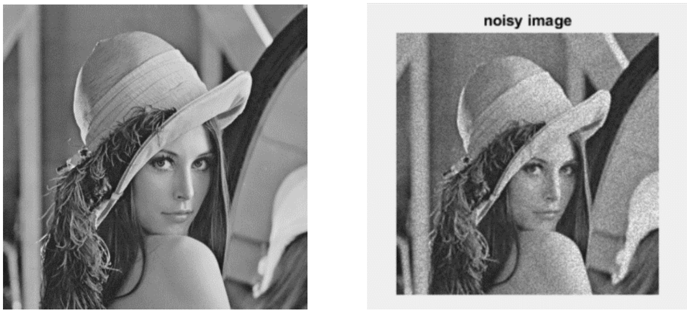

Fig. 1(a) Lena Image (b) Noisy Image

Comparison of power of signal to noise ratio is shown in fig. 2.

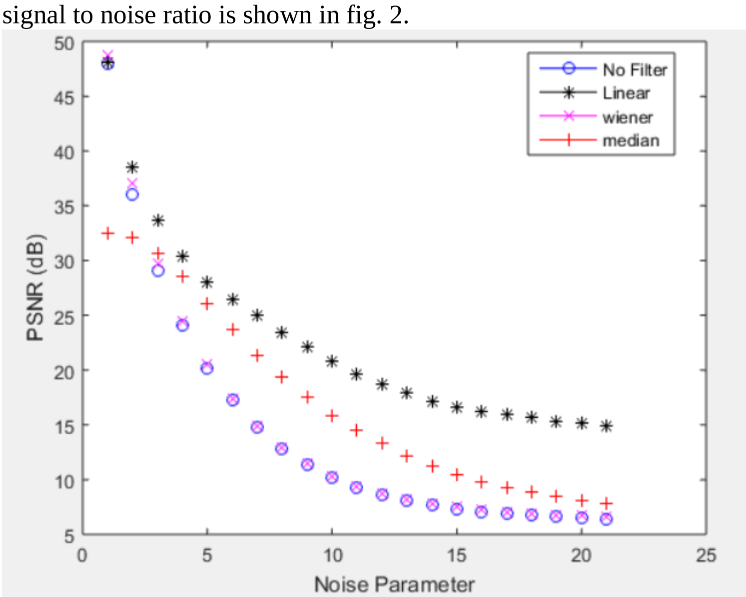

Fig. 2 Signal to Noise Ratio Plot for Median, Wiener and Wavelet filter

Comparison table is shown below, according to which signal to noise ratio for wavelet based linear filter performed best.

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Table 1: PSNR values for median, wiener and wavelet filter

PSNR Values for Different Filters

Square Scale Parameter	PSNR using Linear Filter	PSNR using Wiener Filter	PSNR using Median Filter	PSNR without Filter
0.01	48.0493	48.7797	32. 5183	36. 0319
0.02	38.4763	36.9949	32.0717	29.1072
0.03	33.7215	29.6810	30.6536	24.0360
0.04	30.3711	24.5040	28.4894	20.2137
0.05	27.9459	20.5352	26.0590	17.1874
0.06	26.2779	17.4436	23.5526	14.7609
0.07	24.9068	14.7609	21.2631	12.8450
0.08	23.5037	12.9239	19.4225	11.3055
0.09	22.1294	11.4413	17.5357	10.1344
0.1	20.8380	10.2617	15.8606	9.2619

V. Conclusion

This paper concludes that wavelet based image denoising is better as compared to spatial type of denoising methods. Basics of image processing, image denoising methods and details of denoising is discussed in this research work. Power of signal to noise ratio of noisy image, denoising using median filter, denoising using wiener filter is calculated and results are plotted to compare performance. Linear filter using wavelet transform is performed best. Performance of wiener filter is better when noise level is low and performance of median filter is better when noise level is high. Hence it can be concluded that median filter is better as compared to wiener filter.

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