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Image De-noising: Analysis of Standard and Normal Grey Images Using Different Image Formats

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Abstract**—**In this paper, the investigations of de-noising experiment are applied to grey images. The various conventional and special filters are applied to the noisy images. The PSNR and MSE values of original image and noisy image are calculated. We added spackle noise for performance verification. We used different filters like Mean, Median, Wiener, and Bilateral & Spatial The final results represents that the best results were given by spatial filter, wiener and bilateral filter for grey images.

Keywords**—**Denoising; speckle noise; linear filters; thresholding.

I. Introduction

Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subfield of digital signal processing, digital image processing has many advantages over analog image processing; it allows a much wider range of algorithms to be applied to input data, and can avoid problems such as the build-up of noise and signal distortion during processing. Image de-noising is often used in the field of photography or publishing where an image was somehow degraded but needs to be improved before it can be printed. For this type of application we need to know something about the degradation process in order to develop a model for it. When we have a model for the degradation process, the inverse process can be applied to the image to restore it back to the original form. This type of image restoration is often used in space exploration to help eliminate artifacts generated by mechanical jitter in a spacecraft or to compensate for distortion in the optical system of a telescope.

Binary images are the simplest type of images and can take only two discrete values, black and white. Black is represented with the value '0' while white with '1'. A binary image finds applications in computer vision areas where the general shape or outline information of the image is needed. They are also referred to as 1 bit/pixel images. Gray-scale images are known as monochrome or one-color images. The images used for experimentation purposes in this research are all gray-scale images. They contain no color information. They represent the brightness of the image.

Various De-noising and Filtering Techniques

Various de-noising techniques have been proposed so far and their application depends upon the type of image and noise present in the image. Image de-noising is classified in three Categories: Spatial Filtering, Transform Domain Filtering and Wavelet thresholding Method.

Images are often corrupted with noise during acquisition, transmission, and retrieval from storage media. Many dots can be spotted in a Photograph taken with a digital camera under low lighting conditions [1]. A noise is also introduced in the transmission medium due to a noisy channel, errors during the measurement process and quantization of data for digital process.

Objectives of Any Filtering Approach Are

I. To provide a visually natural appearance.
II. To suppress the noise effectively in uniform regions.
III. To preserve edges and other similar image characteristics.

The most popular and efficient method for image de-noising is the bilateral filter. The bilateral filter is a nonlinear weighted averaging filter. The weights of bilateral filter depend on both the spatial distance and the intensity distance with respect to the center pixel.

The main feature of the bilateral filter is its ability to preserve edges while doing spatial smoothing. The bilateral filter is a robust filter because of its range weight, pixels with different intensities. It averages local small details and ignores outliers. The main drawback in bilateral filter is its incapacity in eliminating salt-and-pepper noise. The second drawback of the bilateral filter is that it produces staircase effect and it is also single resolution in nature.

Another de-noising filter recently proposed is spatial correlation filter. This filter gives very efficient and accurate results. We implemented conventional as well as these recently proposed filter in MATLAB. In this section, we will compare the de-noising performance of the methods by using synthetic and real noisy images.

II. Image De-Noising Methods

There are many different kinds of image de-noising algorithms.

1. Mean Filter

Mean filter is an example of a linear filter. This filter replaces each pixel value in the images with the average value of its neighbors including itself. We select an odd size window with center element as the processing pixel & then replace the

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processing pixel with the average of the window pixels. This filter is mainly used for removal of Salt & Pepper noise but results some blurring at the edges [2].

2. Median Filter

Median filter is an example of a non-linear filter. Median filtering is quite useful in getting rid of Salt and Pepper type noise. In median filter de-noising firstly select an odd size window with center element as the processing pixel & then store the elements in 1-D array. Then sorted the pixel value in ascending or descending order and then replace the processing pixel with the midpoint of the 1-D array.

3. LMS Adaptive Filter

An adaptive filter does a better job of de-noising images compared to the averaging filter. The fundamental difference Between the mean filter and the adaptive filter lies in the fact that the weight matrix varies after each iteration in the adaptive filter while it remains constant throughout the iterations in the mean filter.

Adaptive filters are capable of de-noising non-stationary images, that is, images that have abrupt changes in intensity. Such filters are known for their ability in automatically tracking an unknown circumstance or when a signal is variable with little a prior knowledge about the signal to be processed. In general, an adaptive filter iteratively adjusts its parameters during scanning the image to match the image generating mechanism [3], [4]. This mechanism is more significant in practical images, which tend to be non stationary. Compared to other adaptive filters, the Least Mean Square (LMS) adaptive filter is known for its simplicity in computation and implementation. The basic model is a linear combination of a stationary low-pass image and non stationary high-pass component through a weighting function. Thus, the function provides a compromise between resolution of genuine features and suppression of noise.

a) Bilateral Filter

Bilateral filter [5] is firstly presented by Tomasi and Manduchi in 1998. The concept of the bilateral filter was also presented in [6] as the ‘susan’ filter and in [7] as the neighborhood filter. It is mentionable that the Beltrami flow algorithm is considered as the theoretical origin of the bilateral filter [8], [9], which produce a spectrum of image enhancing algorithms ranging from the L_2 linear diffusion to the L_1 non-linear flows. The bilateral filter takes a weighted sum of the pixels in a local neighborhood; the weights depend on both the spatial distance and the intensity distance. In this way, edges are preserved well while noise is averaged out. Paris and Durand [10] analyzed accuracy in terms of bandwidth and sampling, and derive criteria for down sampling in space and intensity to accelerate the bilateral filter by extending an earlier work on high dynamic range images.

5. Spatial Filtering

A traditional way to remove noise from image data is to employ spatial filters. Spatial filters can be further classified into non-linear and linear filters.

a) Non-linear filters

With non-linear filters, the noise is removed without any attempts to explicitly identify it. Spatial filters employ a low pass filtering on groups of pixels with the assumption that the noise occupies the higher region of frequency spectrum. Generally spatial filters remove noise to a reasonable extent but at the cost of blurring images which in turn makes the edges in pictures invisible. In recent years, a variety of nonlinear median type filters such as weighted median [11], rank conditioned rank selection [12], and relaxed median [13] have been developed to overcome this drawback.

b) Linear filters

A mean filter is the optimal linear filter for Gaussian noise in the sense of mean square error. Linear filters too tend to blur sharp edges, destroy lines and other fine image details, and perform poorly in the presence of signal-dependent noise. The wiener filtering [14] method requires the information about the spectra of the noise and the original signal and it works well only if the underlying signal is smooth. Wiener method implements spatial smoothing and its model complexity control correspond to choosing the window size. To overcome the weakness of the Wiener filtering, Donoho & Johnstone proposed the wavelet based de-noising scheme in [15], [16].

6. 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.

a) Spatial-frequency filtering

Spatial-frequency filtering refers use of low pass filters using Fast Fourier Transform (FFT). In frequency smoothing methods, the removal of the noise is achieved by designing a frequency domain filter and adapting a cut-off frequency when the noise components are de-correlated from the useful signal in the frequency domain.

These methods are time consuming and depend on the cut-off frequency and the filter function behavior. Furthermore, they may produce artificial frequencies in the processed image.

b) Wavelet domain

Filtering operations in the wavelet domain can be subdivided into linear and nonlinear methods.

Linear filters

Linear filters such as Wiener filter in the wavelet domain yield optimal results when the signal corruption can be modeled as a Gaussian process and the accuracy criterion is the mean square error (MSE) [17], [18]. However, designing a filter based on this assumption frequently results in a filtered image that is more visually displeasing than the original noisy signal, even though the filtering operation successfully reduces the MSE. In [19] a wavelet-domain spatially adaptive FIR Wiener filtering for image de-noising is proposed where wiener filtering is performed only within each scale and intra scale filtering is not allowed.

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Non-linear threshold filtering

The most investigated domain in de-noising using Wavelet Transform is the non-linear coefficients thresh holding based methods. The procedure exploits the property of the wavelet transform and the fact that the Wavelet Transform maps white noise in the signal domain to white noise in the transform domain. Thus, while signal energy becomes more concentrated into fewer coefficients in the transform domain, noise energy does not. It is this important principle that enables the separation of signal from noise. The procedure in which small coefficients are removed while others are left untouched is called Hard thresh holding. But the method generates spurious blips, better known as artifacts, in the images as a result of unsuccessful attempts of removing moderately large noise coefficients. To overcome the demerits of hard thresh holding, wavelet transform using soft thresh holding was also introduced in [20].

In this scheme, coefficients above the threshold are shrunk by the absolute value of the threshold itself. Similar to soft thresh holding, other techniques of applying thresholds are semi-soft and Garrote thresh holding [21]. Most of the wavelet shrinkage literature is based on methods for choosing the optimal threshold which can be adaptive or non-adaptive to the image.

III. De-Noising Experiment Applied to Grey Images

The first de-noising experiment is applied to grey images. The various conventional and special filters are applied to the noisy images. The PSNR and MSE values of original image and noisy image are calculated. We also calculated PSNR and MSE of original and de-noised image for performance comparison. The figures from 1 to 4 shows the results. We added spackle noise for performance verification. The input image in each figure has different format. The Performance Comparison in terms of Signal to Noise Ratio (PSNR and MSE) of various filters is:

IV. Results

Figure 1 to 4 represents the detailed image outputs of different filters used. Table I to IV represents that the PSNR & MSE values. For example- the values for original input image without filter were 25.4047 & 187.3292. We used different filters like Mean, Median, Wiener, and Bilateral & Spatial. The PSNR value should increase and MSE value should decrease. After analyzing all filter values, it can be clearly seen that among all these filters the best results were given by Spatial filter, wiener and bilateral filter for grey images.

Table I. PSNR & MSE values of various de-noising algorithms of grey image of JPG format.

Method	Grey Image of JPG	
	PSNR	MSE
Without Filter	25.4047	187.3292
Mean filter	27.1191	126.2309
Median filter	28.8055	85.6105
Wiener filter	29.8307	67.6094
Bilateral filter	29.6143	71.0633
Spatial correlation filter	25.8207	70.2200

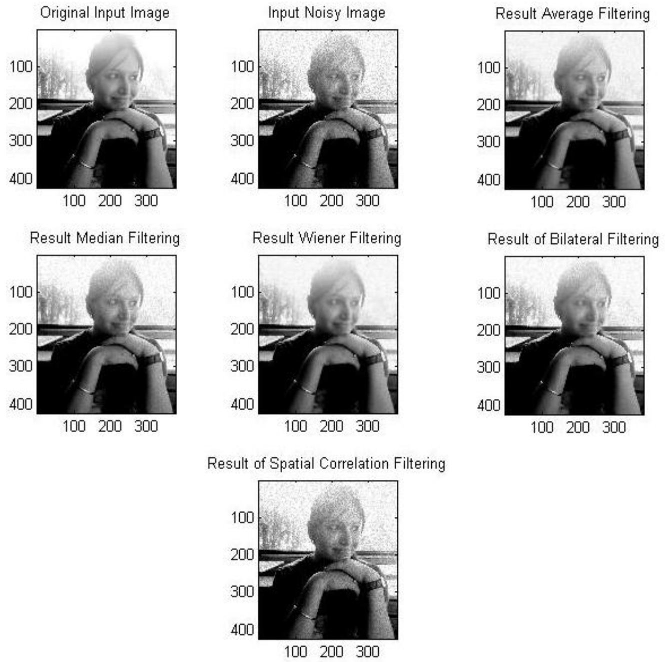

Fig. 1. Results of de-noising filters applied to grey image of JPG format.

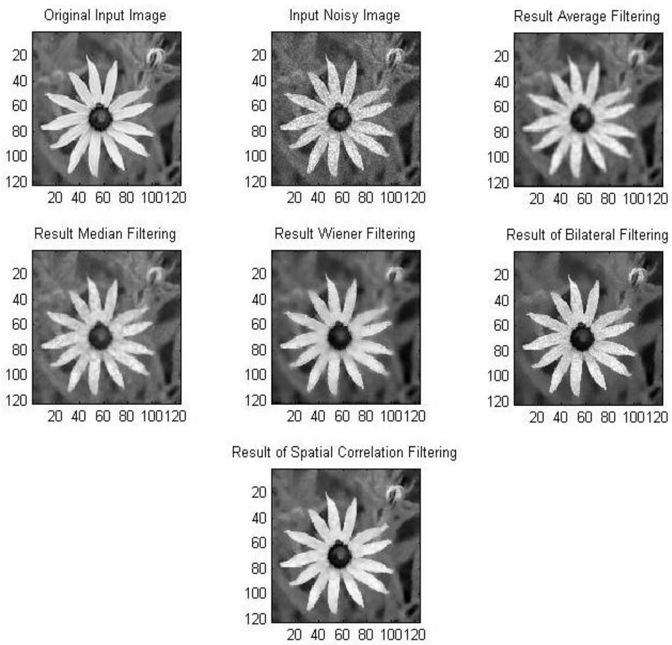

Fig. 2. Results of de-noising filters applied to grey image of BMP format.

Table II. PSNR & MSE values of various de-noising algorithms of grey image of BMP format.

Method	Grey Image of BMP	
	PSNR	MSE
Without Filter	25.9834	163.9596
Mean filter	25.1608	198.1551
Median filter	26.9310	131.8203
Wiener filter	27.3194	120.5414
Bilateral filter	28.9445	82.9141
Spatial correlation filter	30.3974	59.3390

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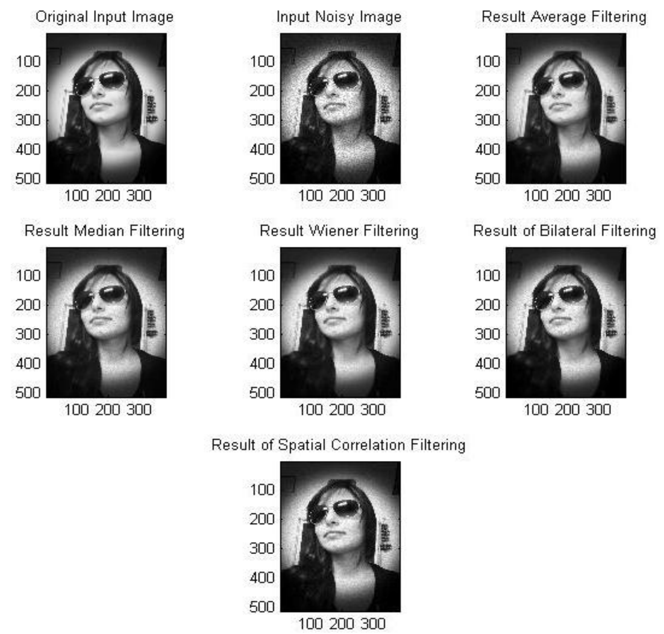

Fig. 3. Results of de-noising filters applied to grey image of PNG format.

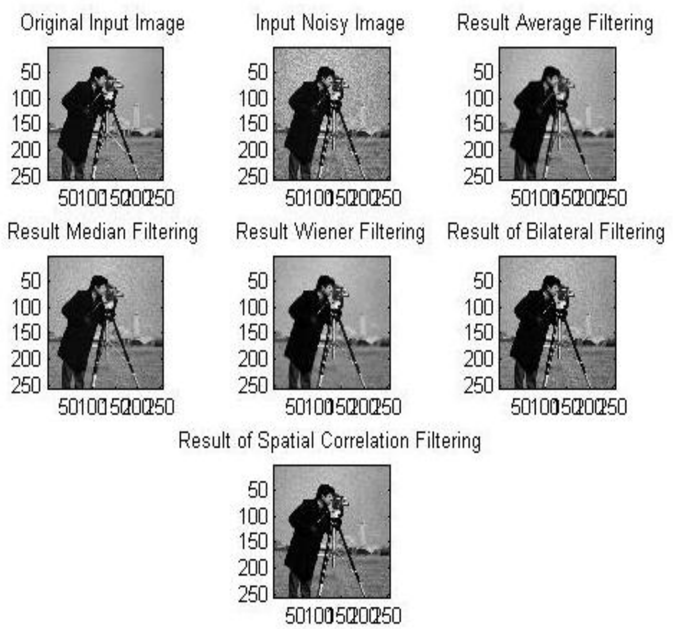

Fig. 4. Results of de-noising filters applied to Standard grey image of JPG format.

Table III. PSNR & MSE values of various de-noising algorithms of grey image of PNG format.

Method	Grey Image of PNG	
	PSNR	MSE
Without Filter	26.8571	134.0806
Mean filter	32.1206	39.9044
Median filter	31.1422	49.9873
Wiener filter	33.0283	32.3781
Bilateral filter	31.7837	43.1234
Spatial correlation filter	32.2271	38.9381

Table IV. PSNR & MSE values of various de-noising algorithms of a standard grey image of JPG format.

Method	Grey Image of JPG	
	PSNR	MSE
Without Filter	25.5539	181.0041
Mean filter	23.8870	265.6945
Median filter	25.3048	191.69211
Wiener filter	27.9963	103.1452
Bilateral filter	29.3759	75.0747
Spatial correlation filter	30.5223	57.6568

V. Conclusion and Future Scope

The purpose of this paper is to present a survey of digital image de-noising approaches. As images are very important in each and every field so, Image De-noising is an important preprocessing task before further processing of image like segmentation, feature extraction, texture analysis etc. The above survey shows the different type of noises that can corrupt the image and different type of filters which are used to improve the noisy image. The study of various de-noising techniques for digital images shows that spatial filters outperforms the other standard spatial domain filters.

As the future perspective can be seen, the mentioned methods can be implemented that to look how it can be used on different images. With different spatial resolution, different behaviors of same image would be quite interesting. Since selection of the right de-noising procedure plays a major role, it is important to experiment and compare the methods. As future research, we would like to work further on the comparison of the de-noising techniques. If the features of the de-noised signal are fed into a neural network pattern recognizer, then the rate of successful classification should determine the ultimate measure by which to compare various de-noising procedures.

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