Chapter 4

Hybrid Bilateral Filtering Technique for Salt and Pepper Noise

Abstract- In this chapter a new hybrid bilateral filtering technique is proposed to improve the denoising process of digital images. Salt and pepper noisy image is used as input image. We use the median filter and bilateral filter to improve the quality of denoised images. Two images are selected for denoising process. This technique gives better result than existing techniques. The quality of the denoised image is measured by statistical quantity measure PSNR (Peak Signal- to- Noise Ratio).

4.1 Introduction

In the field of image processing, linear filters are used as primary tools for image enhancement and restoration because it is easy to design and implement them. However, they give satisfactory performance in many applications.

In image processing application, linear filters do not remove Gaussian and Mixed Gaussian impulse noise effectively. Median filter introduced in 1970 by Tukey [1], is now used in reducing noise and smoothing the images. An adaptive median filter is the best filter to remove salt and pepper noise of image. A bilateral filter is a non-linear, edge-preserving and noise-reducing smoothing filter for images. The objective of the present study is to develop new hybrid filtering technique and evaluate its performance on images.

4.2 Types of Noise

Salt and pepper noise: This type of noise is isolated pixels having a value of either 0(black) or 255(white). Such noise is denoted by salt and pepper noise [4]. By isolated we mean that they have a value very different from their neighbors.

Gaussian noise: Gaussian noise is statistical noise [5] that has probability density function (PDF) of the normal distribution (also known as Gaussian distribution).The Gaussian distribution depend on only two parameters, which mean and variance.

Periodic noise: Periodic noise in an image arises typically from electrical or electromechanical interference during image acquisition [7]. The image is severally corrupted by sinusoidal noise of various frequencies. Periodic noise can be analyzed and filtered quite effectively using frequency domain techniques. The basic idea is that periodic noise appears as concentrated bursts of energy in the Fourier transform at location corresponding to the frequencies of the periodic interface. The approach is to use a selective filter to isolate the noise. The Three types of selective filters are available such as bandreject, bandpass and notch filter.

4.3 Types of Filter

(i) Median filter: Median filter is a nonlinear filter and is broadly used for salt and pepper noise and also for impulse noise. In salt and pepper noise, black dot is called the pepper and white holes are called salt. It performs better in comparison to the linear filter. It simply replaces each pixel values by the median of intensity level in the neighborhood pixel.

(ii) Wiener filter: Wiener filter is a linear filter. The Wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing. It removes the additive noise and inverts the blurring simultaneously.

(iii) Harmonic mean filter: This filter can be either passive or active. Usually, it would completely smooth the waveform, but is designed to minimize the specific harmonics that are the greatest offenders. The harmonic mean filter is better in removing Gaussian-type noise and preserving edge features than the arithmetic mean filter. The harmonic mean filter is better in removing positive outliers.

(iv) Geometric mean filter: The geometric mean filter is better in removing Gaussian-type noise and preserving edge features than the arithmetic mean filter. The geometric mean filter is more susceptible to negative outliers.

(v) Bilateral filter: It is the non linear filtering process [8], ability of these filtering techniques is to decompass an image into different scales without causing holes after modification has been made. It is used in computational photography applications such as tone mapping ,style transfer, relighting and denoising .This filter was proposed by C. Tomasi and R.Manduchi [1] in 1998 as an efficient technique of noise reduction.

4.4 Parametric Description

Mean Square Error (MSE), is computed by averaging the squared intensity of the difference in original (input) image and the resultant (output) image pixels where X(i,j)-Y(i,j) is the error difference between the original and the distorted images.

$$MSE = \frac{1}{HW}\sum_{i=1}^{H}\sum_{j=1}^{W}[X(i,j) - Y(i,j)]^2 \qquad (4.1)$$

Peak Signal-to-Noise Ratio (PSNR), Signal–to-noise ratio (SNR) is a mathematical measure of image quality based on the pixel difference between two images. The SNR measure is an estimate of the quality of reconstructed image compared with an original image. PSNR is defined as

$$PSNR = 10\log_{10}\frac{255^2}{MSE}(dB) \qquad (4.2)$$

Here 255 corresponds to the 8-bit image. The PSNR is basically the SNR when all pixel values are equal to the maximum possible value.

4.5 Proposed Image Denoising Technique

An image denoising technique is proposed for the image which is affected by the salt and pepper noise.

Our proposed technique structure is illustrated in the Fig below:

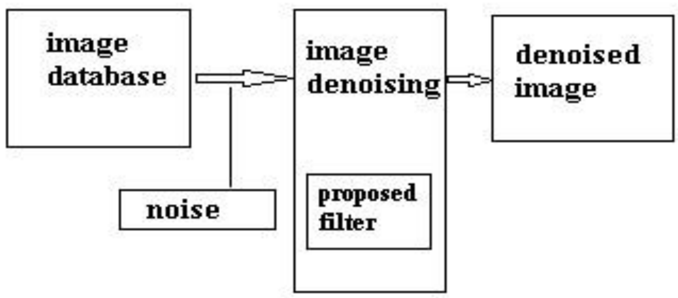


Fig 4.1: Block diagram of our proposed image denoising technique

At first the noise image is given to the image denoising process. We use bilateral filter [2] and median filter for the image denoising process [3].

The procedure of image denoising by proposed filter is given below.

Step 1: Take the degraded image by pepper and salt noise.

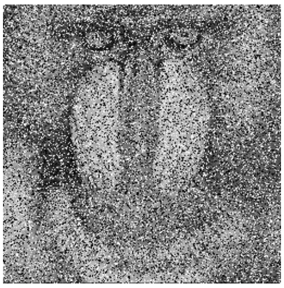
Step 2: Use the proposed filter for denoising process.

Step 3: Output image is denoised image.

4.6 Result and Discussion

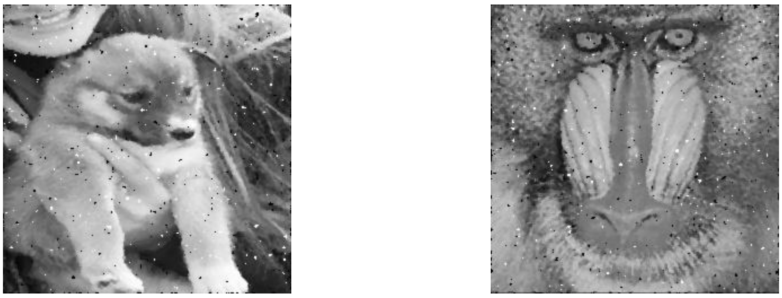
The results are given in the table for the standard 256 X 256 image size using salt and pepper noise with three different noise variances.

(a)



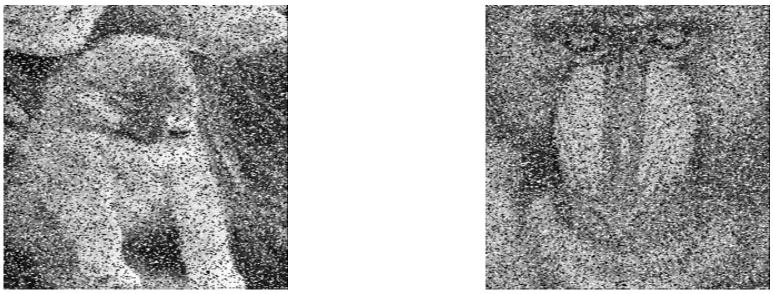
(b)

Fig 4.2: Noisy images by salt and pepper with noise variance 0.3



(a) (b)

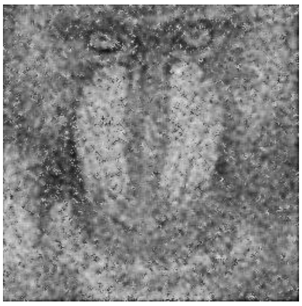
Fig 4.3: images when filtered by proposed filter.



(a) (b)

Fig 4.4: Images when filtered by median filter.

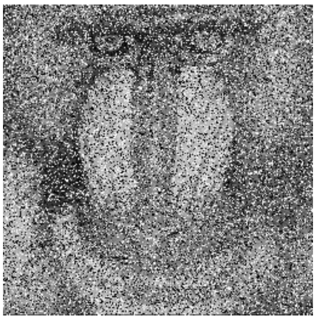
(a)



(b)

Fig 4.5: Images when filtered by Wiener filter.

(a)



(b)

Fig 4.6: Images when filtered by bilateral filter

We now tabulate the PSNR values of images (a) and (b) obtained from the proposed filter, Wiener filter, bilateral filter and median filter for σ^2= 0.1, 0.2, 0.3 and 0.4.

Noise Variance (σ^2)	Images	PSNR (in dB) for Median Filter	PSNR (in dB) for Bilateral Filter	PSNR (in dB) for Wiener Filter	PSNR (in dB) for Proposed Filter
0.1	a	65.96	64.62	68.83	78.11
	b	66.26	65.04	68.77	73.16
0.2	a	63.08	61.55	67.08	75.50
	b	63.50	62.13	67.49	72.08
0.3	a	61.31	59.76	65.73	71.13
	b	61.81	60.33	66.57	69.10
0.4	a	59.95	58.47	64.75	66.95
	b	60.53	59.05	65.83	66.55

Table 4.1: PSNR values in dB for images obtained after bilateral filter, Wiener filter, median filter and proposed filter for σ^2= 0.1,0.2,0.3 and 0.4.

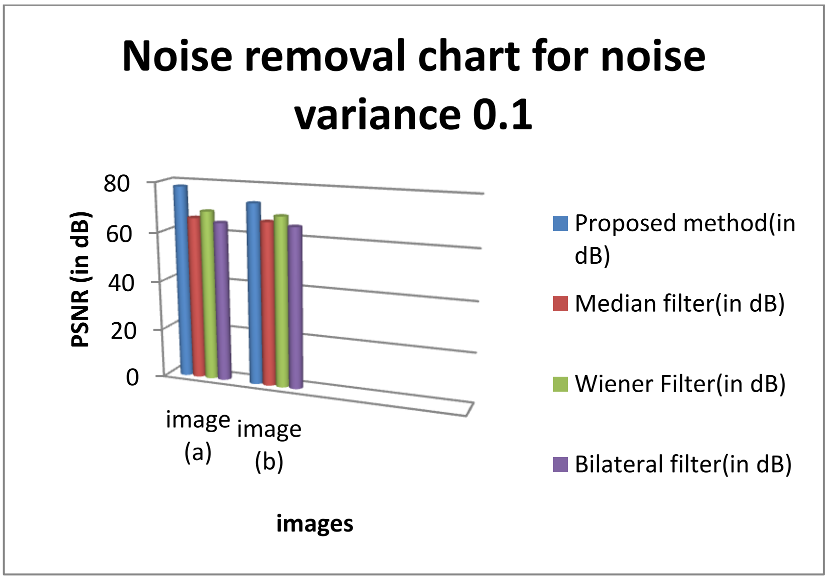


Fig 4.7: Noise removal performance of our implemented denoising filter (noise variance 0.1) and existing filtering methods

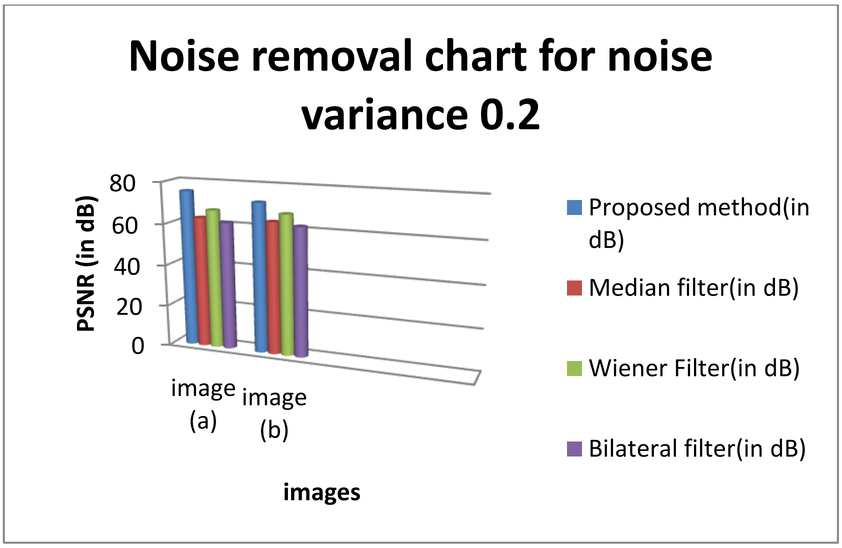


Fig 4.8: Noise removal performance of our implemented denoising filter (noise variance 0.2) and existing filtering methods

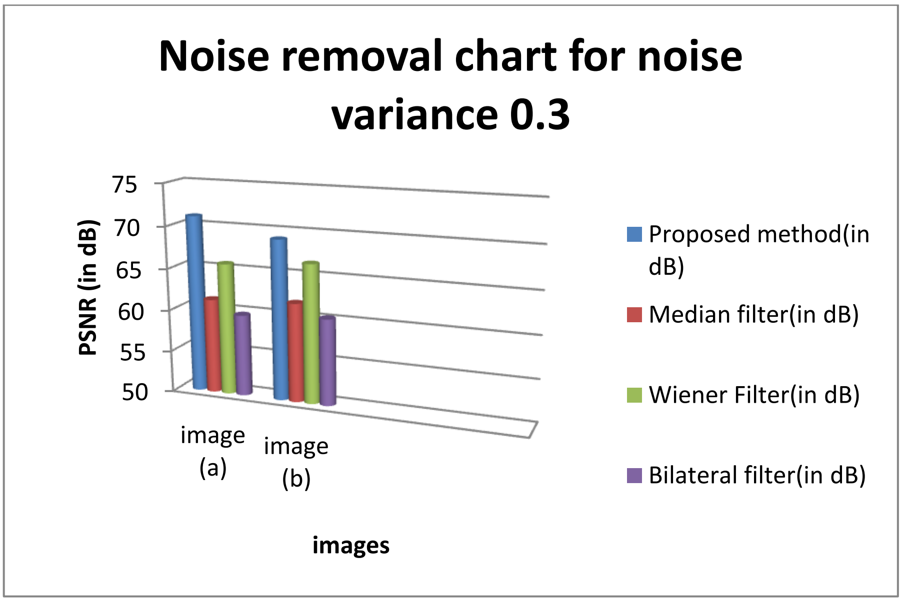


Fig 4.9: Noise removal performance of our implemented denoising filter (noise variance 0.3) and existing filtering methods

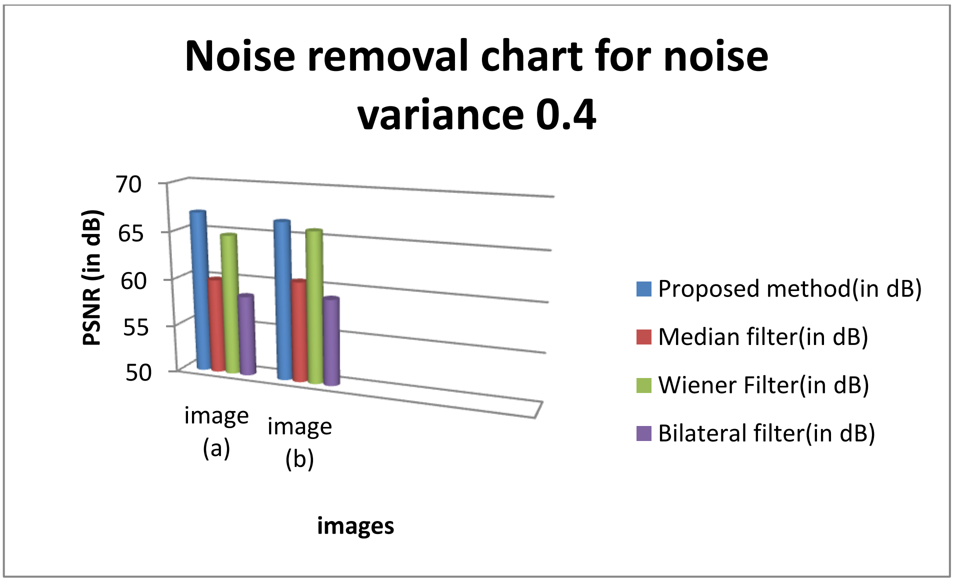


Fig 4.10: Noise removal performance of our implemented denoising filter (noise variance 0.4) and existing filtering methods

4.7 Conclusion

In this chapter we have implemented a new hybrid filter to remove the impulse noise from the images. To illustrate the efficiency of the implemented scheme, we have simulated the new scheme along with the existing ones and various restored measures have been compared. All the filtering techniques have been simulated in MATLAB 7.1 with Core 2 Duo Processor.

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