Bilateral Filter Based Image Denoising

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***Abstract*— The bilateral clarify is a nonlinear filter goes spatial averaging without smoothing edges and It has shown to be an efficient image denoising technique. We can also apply this method to the blocking artifacts reduction. A large issue with the application of the bilateral filter is the selection of the filter parameters which could change the results significantly. In other hand research interest of bilateral filter is an advance of the computation speed. Concerning there are several contributions of this research firstly it is an empirical study of the optimal bilateral filter parameter selection in image denoising. Here I propose a development of bilateral filter, a multi-resolution bilateral filter where this method is applied to the low-frequency sub-band of a signal decomposed using through a wavelet filter bank. The multi-resolution bilateral filter is combined with wavelet thresholding to form a new image denoising framework, which turns out to be very effective in eliminating noise in real noisy images. Secondly, the contribution is that spatially adaptive method to reduce compression artifacts to escape over smoothing texture regions and to completely eliminate blocking and ringing artifacts. In this paper texture region and block, boundary discontinuities are first detected these are then used to control/adapt the spatial and intensity parameters of the bilateral filter. The experimental result could prove that the adaptive method can improve the quality of restored images significantly better than the standard bilateral filter. Thirdly the contribution is the progress of the fast bilateral filter, in which I use a combination of multi-windows to approximate the Gaussian filter more accurately.**

The bilateral filter is a weighted convolution filter with each pixels weight dependent on the distance from the center both in space and value. Its advantage preserving properties make it suitable for a number of applications including detail enhancement, noise removal, and tone mapping.

Keywords—Bilateral Filter; Image Denoising

I. INTRODUCTION

Different sources of noise can be found in a digital image. For instance, we can tell about dark noise which is generally the cause of thermally generated electrons of at sensing sites. It is highly dependent to the sensor temperature as well as proportional to the exposure time. Another source of noise that forms due to the quantum uncertainty in photoelectron generation is called the shout noise. This noise is characterized by Poisson distribution. Other two types of noises that occur while converting the number of electrons generated to pixel intensities are called amplifier noise and quantization noise. There are many factors those influence the overall noise characteristics in an image. These are – sensor type, temperature, exposure time, pixel dimensions and ISO speed. Noise is in general spatial position and channel dependent.

Image de-noising is an important issue in the field of image processing. It is an important foundation for the other image processing, such as image recognition, understanding. In accordance with processing domains of the image denoising, the existing algorithms can be divided into two categories: spatial domain ones and transform domain ones [3].

The former ones refer to those who process image pixels directly. While, the later ones need to map the images that are to de-noised to the transform domain, and process them according to the nature of their transform domain coefficients, and finally transform them into space domain. Spatial domain methods include linear spatial filtering and nonlinear spatial filtering. Linear spatial filtering method is also known as mean filtering, which reduce noise in the image through linear filtering. Nevertheless, it will bring in blurry, and the level of blurring is proportional to the extent of the neighborhood radius [4]. Median filter is one of nonlinear spatial filters, and its basic idea is to use middle pixel gray values in the neighborhood instead of the pixel gray values. This algorithm can reduce the level of noise in the premise of preserving edges or textures. Frequency domain filtering methods include Fourier method and wavelet method [5, 6].

Gaussian filter has been widely used in the early denoising applications, but it tends to remove image details (such as textures and edges) in the process of de-nosing. So the literature [7] proposed the bilateral filter method to denoise images. In this method, the convolution kernel is also related to inter-pixel colors (grays) besides geometric distances. Bilateral filter can effectively solve the problems of the Gaussian filter that we have discussed above. However, we note that the bilateral filter just adds the two factors (geometric distance factor and color difference factor) simply, resulting in that the color factor plays a decisive role, and the distance factor is ignored in most cases. Therefore, we propose to use the theory of weights to weight the two factors in order to achieve equal status of the two factors.

II. LITERATURE SURVEY

In order to solve the image denoising and compression artifacts reduction problems, this thesis consists of five parts. Here given a comprehensive literature review, which covers the most popular and advanced researches in the certain fields. In C this paper, I will explain the elaborate proposed methods for image denoising. A multi resolution bilateral filter is applied to the image for real noise elimination. Here, I will give the full results of the experiments in image denoising. Then I will discuss the framework of my method in compression artifacts reduction, which uses a spatial adaptive bilateral filter and all the experiment results and data for compression artifacts reduction are presented.

III. IMPLEMENTATION

Bilateral filtering algorithm is implemented in following steps are explained in detailed as given in fig 1 .

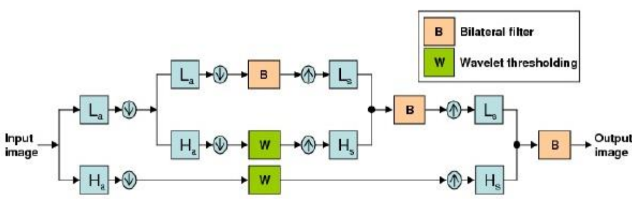


Fig 1 : Design steps of bilateral algorithm

As per our previous discussion, it is not necessary that image noise has to be white; it may have different spatial frequency (coarse-grain and fine-grain) characteristics. To eliminate noise in signals, multi resolution analysis is an effective proven tool. Through this, noise and image information can be differentiated better at one resolution level than another. Therefore, we have decided to put the bilateral filter in a multi resolution framework: referring to Figure1, with wavelet decomposition, a signal is decomposed into its frequency sub-bands. In case of, when the signal is reconstructed back, bilateral filtering is applied to approximation sub-bands. The multi resolution bilateral filtering is not like the standard single-level bilateral filtering as it has the potential to remove low-frequency noise components. Bilateral filtering works in approximation up-bands. Additionally, wavelet thresholding can be applied to the detail sub-bands; through this, noise component can be identified and removed effectively. In combination of bilateral filtering and wavelet thresholding this new image denoising framework works.

IV. ALGORITHM

This section gives the detailed explanation of the algorithm and the proposed method that we have tried to bring the bilateral filtering in image denoising .

A bilateral filter is an edge-preserving and noise reducing smoothing filter. Here, the intensity value at each pixel in an image is replaced by a weighted average of intensity values from nearby pixels. And, this weight is based on a Gaussian distribution. Euclidean distance and the radiometric differences (differences in the range, e.g. color intensity) are two things on what the weights actually depend. This systematically preserves edges by looping through each pixel and according weights to the adjacent pixels accordingly which in a result gives a spectrum of images with enhanced algorithms ranging from the L2 linear diffusion to the L1 non-linear flows. In a local neighborhood, the bilateral filter takes a weighted sum of the pixels; this weight depends on intensity distance and spatial distance. Thus the edges are preserved well and noise is also averaged out.
In the following math, at a pixel location x, the output of a bilateral filter is calculated as –

$$\tilde{I}(\mathbf{x}) = \frac{1}{C} \sum_{y \in N(x)} e^{\frac{-\|\mathbf{y}-\mathbf{x}\|^2}{2\sigma_d^2}} e^{\frac{-|I(\mathbf{y})-I(\mathbf{x})|^2}{2\sigma_r^2}} I(y)$$

Calculation Fig : 1.1

In figure 1.1, $\sigma/_d$ and $\sigma/_r$ are the parameters controlling the fall-off of weights in spatial and intensity domains, respectively, N(x) is a spatial neighborhood of pixel I(x0, and C is the normalization constant:

$$C = \sum_{y \in N(x)} e^{\frac{-\|\mathbf{y}-\mathbf{x}\|^2}{2\sigma_d^2}} e^{\frac{-|I(\mathbf{y})-I(\mathbf{x})|^2}{2\sigma_r^2}} \quad (1.2)$$

Calculation fig : 1.2

From figure 1.2 we can see the illustrated 1D bilateral filter. The top right image is the input of noisy signal. The left top image illustrates the intensity Gaussian; on the other hand, the mid image shows the middle of the special Gaussian.

Here is algorithm :

Input: Noised Image.
Output: Denoised Image.
% Convert to grayscale for grayscale mode bilateral filtering.
Image decomposition (L_a,H_a).
Calculate the weights (distance & intensity).
For L_a
  Decompose the component (L_a1,H_a1).
    Calculate the weights.
      Apply bilateral filtering onL_a1.
        DecomposeL_a1.
          Compute weights
            Apply wavelet thresholding onH_a1.
              Compose component.
End for
ForH_a
      Calculate weights.
          Wavelet thresholding.
End for
Compose
Bilateral filter

End.

V. RESULT AND DISCUSSION

(a) original image (b) noised image (c) denoised image

Sigma=20

(a) original image (b) noised image (c) denoised image

Sigma=25

(a) original image (b) noised image (c) denoised image

Sigma=30

(a) original image (b) noised image (c) denoised image

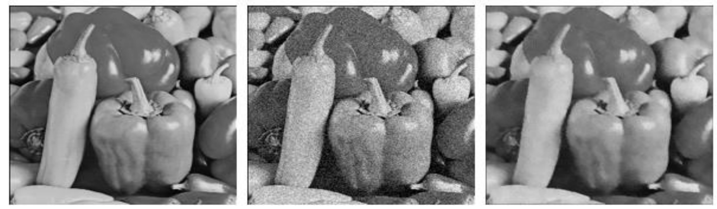
Sigma=20

(a) original image (b) noised image (c) denoised image

Sigma=25

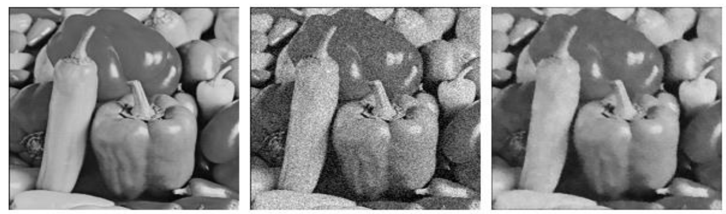
(a) original image (b) noised image (c) denoised image

Sigma=30



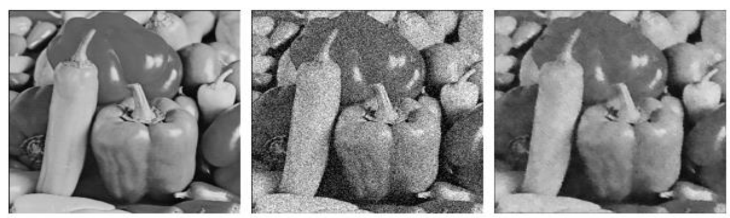
(a) original image (b) noised image (c) denoised image

Sigma=20



(a) original image (b) noised image (c) denoised image

Sigma=25



(a) original image (b) noised image (c) denoised image

Sigma=30

Images		Sigma=20	Sigma=25	Sigma=30
peppers	Bilateral	psnr:24.9670	psnr:24.8646	psnr:24.6703
	Noised image	Psnr:22.2279	psnr:20.3299	psnr:18.7662
barbara	Bilateral	psnr:24.6615	psnr:24.4994	psnr:24.1778
	Noised image	psnr:22.1871	psnr:20.3078	psnr:18.7937
lena	Bilateral	psnr:29.0445	psnr:28.5516	psnr:27.7501
	Noised image	psnr:22.1511	psnr:20.2260	psnr:18.7019

RESULT TABLE : 1

CONCLUSION

In this section of the research, I have made an empirical study of the optimal parameter values for the bilateral filter in image denoising applications and present a multi resolution image denoising framework, which integrates bilateral filtering and wavelet thresholding. In this framework, I decompose an image into low- and high-frequency components, and apply bilateral filtering on the approximation sub-bands and wavelet thresholding on the detail sub-bands. We have found that the optimal $\sigma/_{r}$ value of the bilateral filter is linearly related to the standard deviation of the noise. The optimal value of the $\sigma/_{d}$ is relatively independent of the noise power. Based on these results, we estimate the noise standard deviation at each level of the sub-band decomposition and use a constant multiple of it for the $\sigma/_{r}$ value for bilateral filtering.

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