Image Enhancement Using Guided Image Filter and Wavelet Based Edge Detection

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Abstract - *This paper proposes a new method for image enhancement by incorporating the concept of guided image filter and wavelet based edge detection. Guided image filter is a spatial domain filter performs the filtering by considering the content of the guidance image, which can be the input image itself or another different image. Guided image filter has no gradient distortion and better performance near the edges. Wavelet based edge detection which is a frequency domain approach is used here for edge detection. It has better performance than any other edge detection methods such as Roberts, sobel operators. This method helps to suppress the noise while preserving the edges. The experimental results prove that the proposed image enhancement method outperforms other methods in both subjective and objective quality, peak-signal-to-noise ratio(PSNR).*

Keywords - *Image enhancement, guided image filter, discrete wavelet transform, wavelet based edge detection, peak signal to noise ratio.*

I. INTRODUCTION

An image [Jonathan Sachs 1996-1999] is synonymous to digital image and is very much essential for daily life applications such as satellite television, medical imaging (magnetic resonance imaging, ultrasound imaging, x-ray imaging), computer tomography etc. It is also essential for the researches in the areas of Science and Technology such as geographical information systems and astronomy. The images collected by different type of sensors are generally contaminated by different types of noises.

Digital images may be contaminated by different sources of noise. Noise may be generated due to imperfect instruments used in image processing, problems with the data acquisition process, and interference, all of which can degrade the data of interest. Furthermore, noise can be introduced by transmission errors and compression also. So image enhancement is a necessary task in image processing.

Image enhancement improves the quality (clarity) [Adithya Goyal et.al. 2012] of images for human viewing. It basically improves the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer.

During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations. For example, an image might be taken of an endothelial cell, which might be of low contrast and somewhat blurred. Reducing the noise and blurring and increasing the contrast range could enhance the image. The original image might, have areas of very high and very low intensity, which mask details. An adaptive enhancement algorithm reveals these details. Adaptive algorithms adjust their operation based on the image information (pixels) being processed. In this case the mean intensity, Contrast and sharpness (amount of blur removal) could be adjusted based on the pixel intensity statistics in various areas of the image. There exist many techniques that can enhance a digital image without spoiling it.

The image enhancement methods can broadly be divided in to the following two categories:

1. Spatial Domain Methods
2. Frequency Domain Method

In spatial domain techniques, we directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred in to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the grey levels. As a consequence the pixel value (intensities) of the output image will be modified according to the transformation function applied on the input values.

This paper proposes a new method which combines the spatial and wavelet domain method for image enhancement. The spatial method used is guided image filter and the wavelet domain method is wavelet based edge detection. Many spatial domain methods include bilateral filter, which having the disadvantage of yielding blurring effect, gradient distortion etc. Guided image filtering performs filtering operation based on the guidance image content. This is a edge preserving, gradient distortion less filter. Wavelet based edge detection method has good visual quality than the conventional edge detectors such as canny, sobel etc.

This paper is organized as follows. In section II, proposed method is discussed. Section III introduces guided image filter. Section IV describes wavelet transform. Section V explains the wavelet based edge detection method. Section V presents the experimental results and discussion while concluding remarks are given in section VI.

II. PROPOSED METHOD

The proposed method is a combination of spatial domain method and wavelet domain method. In this proposed method, the noisy image is passed through guided image filter and some amount of noise gets reduced and the image become blur. Next the edge detection is performed. For that, the guided filter undergoes discrete wavelet transform. Form these coefficients, the edges are detected. Finally, the spatial domain and wavelet domain methods are combined together to form the final denoised output.

III. GUIDED IMAGE FILTER

Guided image filter [Kaiming He et.al.] is an explicit image filter, derived from a local linear model; it generates the filtering output by considering the content of a guidance image, which can be the input image itself or another different image. Guided image filter has a fast and non-approximate linear-time algorithm, whose computational complexity is independent of the filtering kernel size. The guided filter output is locally a linear transform of the guidance image. This filter has the edge-preserving

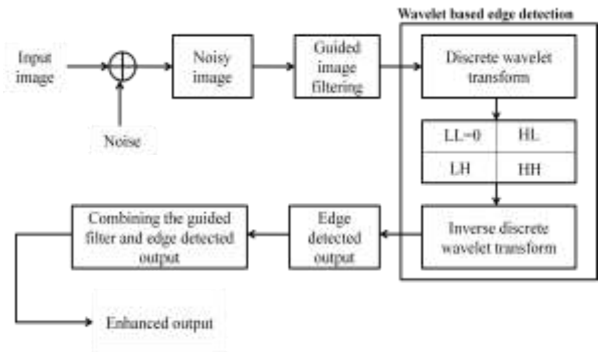

Fig.1. proposed method for image enhancement

smoothing property like the bilateral filter, but does not suffer from the gradient reversal artifacts. Moreover, the guided filter has an O(N) time (in the number of pixels N) exact algorithm for both gray-scale and color images. The guided filter performs very well in terms of both quality and efficiency in a great variety of applications, such as noise reduction, detail smoothing/enhancement, HDR detail smoothing/ enhancement, HDR compression, image matting/feathering and haze removal.

A. Guided filter kernel: We first define a general linear translation- variant filtering process, which involves a guidance image I, an input image p, and output image q. Both I and p are given beforehand according to the application, and they can be identical. The filtering output at a pixel I is expressed as a weighted average:-

$$q_i = \sum_j w_{ij}(p)p_j \quad (1)$$

Where i and j are pixel indexes. The filter kernel Wij is a function of the guidance image I and independent of p. This filter is linear with respect to p.

The guided filtering kernel W_{ij} is given by:-

$$w_{ij}\,(p) = \frac{1}{|w|^2} \sum_{k:(ij)\in w_k} (1 + \frac{(I_i - \mu_k)(I_j - \mu_k)}{\sigma_k{}^2 + \varepsilon} \qquad (2)$$

Where I is the guidance image, p is the input image, w_{ij} is the filter kernel is the variance, k_i is the normalizing parameter, w_k is the window centered pixel at pixel k and μ_k is mean of I.

B. Guided filter algorithm: 1. Read the image say I (gray scale image), it acts as a guidance image.
2. Make p=I, where p acts as our filtering image (gray scale image).
3. Enter the values assumed for r and ε, where r is the local window radius and ε is the regularization parameter.
4. Compute the mean of I, p, I*p.
5.The compute the covariance of (I,p) using the formula:-
 cov_Ip=mean_Ip -mean_I.*mean_p;
6. Then compute the mean of (I*I) and use it to compute the variance using the formula:-
 var_I = mean_II - mean_I .* mean_I
7. Then compute the value of a, b. where a,b are the linear coefficents.
8. Then compute mean of both a and b.
9. Finally obtain the filtered output image q by using the mean of a and b in the formula
 q = mean_a .* I + mean_b;

IV. WAVELET TRANSFORM

The wavelet transform [M. Vijay et.al 2012, Amardeep Kaur and Rakesh Singh 2010] always offering great design flexibility while trying to replace standard image processing techniques, wavelet transforms provides an efficient representation of the image by finely tuned to its intrinsic properties. By combining such representations with simple processing techniques in the transform domain, multiresolution analysis can accomplish remarkable performance and efficiency for many image processing problems. Discrete non redundant wavelet analysis techniques. But after the transform plays a major role in image decomposition stage it introduces some artifacts.

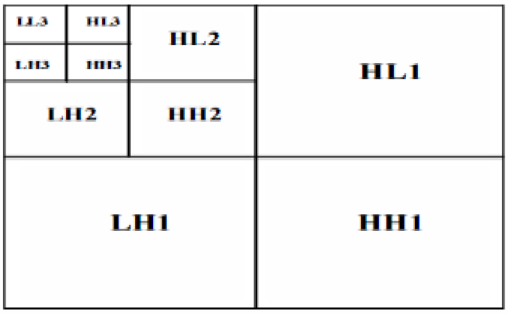

Fig. 2. Image Decomposition (level 3) Using Discrete Wavelet Transform

V. WAVELET BASED EDGE DETECTION

After wavelet decomposition, [D. Sripathi 2003] the horizondal edges of the images are present subband HL subbandof the upper right quadrant. The vertical edges of the image can be similarly identified in the LH subband of the lower left quadrant. To combain this information into a single edge image, simply zero the LL subband of the transform. Then compute the inverse transform and take the absolute value.

VI. RESULTS AND DISCUSSION

Experiments using guided image filter and wavelet based edge detection are conducted on a set of images such as cameraman, peppers, coins, moon, pout, lena and barbara. The images are added with additive white gaussian noise with standard deviation 0.05. The original image is shown in figure 3. Different mages are of different size. So the original image is first resize to [256 256]. Then the original image is added with additive white gaussian noise inorder to generate the noisy image. It is given in figure 4. After the noisy image generation, guided image filter is performed. Figure 5 shows theguided filter output. in guided image filtering, the blurring of the image increases with increase in window size. Next step is wavelet based edge detection. First find the discrete wavelet transform of the image.Then make the lower frequency component as zero. Finally take the inverse wavelet transsform. This is shown in figure 6.Edge detection is also performed using conventional edge detectores.Unwanted edges are detected using this conventional edge detectors is shown in figure 7. Also it has poor visual quality when it is combined with background information.Finally combines the guided filter and edge detected output. It is shown in figure 8.The proposed algorithm helps to preserve the edges in the images.

Fig. 3. Original image

Fig. 4. Noisy image

Fig. 5. Guided filter output

Fig. 6. Wavelet based edge detected output

Fig. 7. Conventional edge detected output

Fig. 8. Proposed method output

VII. CONCLUSION

In the proposed method, it combines both the spatial domain and wavelet domain method. So the output image is a high quality image. The quality analysis of different images is given in the table 1. From the table, it is clear that the PSNR value of original and noisy image is less than the PSNR value of original enhanced output.

Table 1. Quality analysis of different image

Original image	PSNR of Original and Noisy image	PSNR of Original and enhanced image
Cameraman	19.2021	22.8307
Moon	19.6921	23.2099
Pout	18.9984	23.3161
Peppers	19.1492	23.7844
Lena	19.0770	22.9281
barbara	19.1027	21.5345

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