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A Hybrid BiLateral Filter for Image Enhancement

Ramanpreet Kaur [*], Sharanjit Singh, Amardeep Singh

Department of Computer Science and Engineering, Guru Nanak Dev University (G.N.D.U.) Amritsar, Punjab, India

ABSTRACT

To remove the various types of noises that are either added in the image during capturing process or introduced into the image during transmission process, different types of Image Enhancement or noise reduction processes are applied. A good noise reduction method can reduce the noise level as well as preserve details of the image. This paper deals with removing the noise modeled with either a Gaussian or salt & pepper noise simultaneously from the images. The hybrid bilateral filter proposed by me is combination of bilateral filter and alpha trimmed filter. The hybrid bilateral filter is proven to perform better than or at least equal to the traditional bilateral filter. A image containing various degrees of Gaussian, salt & pepper, and mixed noise were used to evaluate the performance of this new denoising method. It is observed that the hybrid bilateral filter performed better than existing bilateral filter in both visual image quality and restored signal quantity.

Keywords : Impulse Noise; Gaussian Noise; Image Denoise ; PSNR;

I. INTRODUCTION

In image processing difficulty is images enhancement and the restoration in the noisy environment [2]. If we want to reduce the noise to enhance quality of images, we can use various image enhancement techniques which are applicable in digital image processing. There are various filters like linear and nonlinear which can remove the noise from images enhance the quality of image

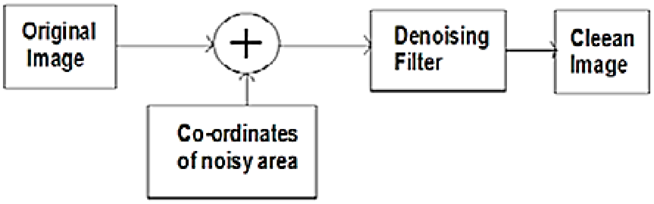

Figure 1. Process of Noise Removal

Hybrid filters [4] are used to remove either additive Gaussian or salt & pepper noise from the image. These include the bilateral filter and alpha trimmed filter.

Types of Noises

Noise is undesired information that contaminates the image. In the image denoising process, information about the type of noise present in the original image plays a significant role.

Typical images are corrupted with noise modeled with either a Gaussian or salt and pepper distribution. Noise is present in an image either in an additive or multiplicative form [3].

An additive noise follows the rule
$C(a, b) = I(a, b) + N(a, b)$,

While the multiplicative noise satisfies
$C(a, b) = I(a, b) \times N(a, b)$,

Where $I(a, b)$ is the original signal, $N(a, b)$ denotes the noise introduced into the signal to produce the corrupted image $C(a, b)$, and (a, b) represents the pixel location.
Following are Types of Noises:

1. Gaussian noise
2. Salt-and-pepper noise

1) *Gaussian Noise*

Gaussian noise is evenly distributed over the signal [2]. It means that each pixel in the noisy image is the addition of the true pixel value and a random Gaussian distributed noise value. As the name indicates, this type of noise has a Gaussian distribution, which has a bell shaped probability distribution function given by.

$$F(g) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(g-m)^2/2\sigma^2}$$

Where g represents the gray level, m is the mean or average of the function and σ is the standard deviation of the noise. Graphically, it is represented as shown in Figure 2.

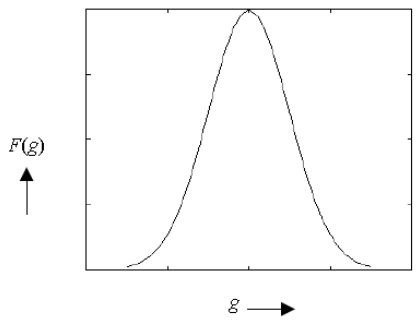

Figure 2. Gaussian Distribution

2) *Salt and Pepper Noise*

Salt and pepper noise is a type of black and white points of light and dark noise. The image sensor, transmission channel and decoding processing form salt and pepper noise [2]. It has only two possible values, A and B. The probability of each is typically less than 0.1. The corrupted pixels are set alternatively to the minimum or to the maximum value, giving the image a “salt and pepper” like appearance. The probability density function for this type of noise is shown in Figure 1.3

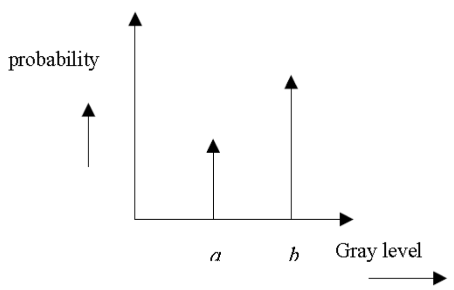

Figure 3. Distribution functions of Salt & Pepper Noise.

II. METHODS AND MATERIAL

1. Bilateral Filter

Bilateral filtering [2] method is based on the Gauss filtering method proposed in dealing with each adjacent pixel gray values. Not only does it take into account the close relationship between space , but also takes into account the gray similar relationship. Its mainly aimed at Gauss filtering. The filter optimizes the image brightness into the Gauss function and products information. Weighted sum of pixels in neighborhood is taken by the bilateral filter [3], the weights of local neighborhood pixel depend on both the intensity and spatial distance respectively. In this way, average pixel value is computed with preservation of edges.

The weighted average is done over a neighborhood S around the center sample $s_o = \{x_o, y_o\}$ whose intensity is $I(s_o)$:

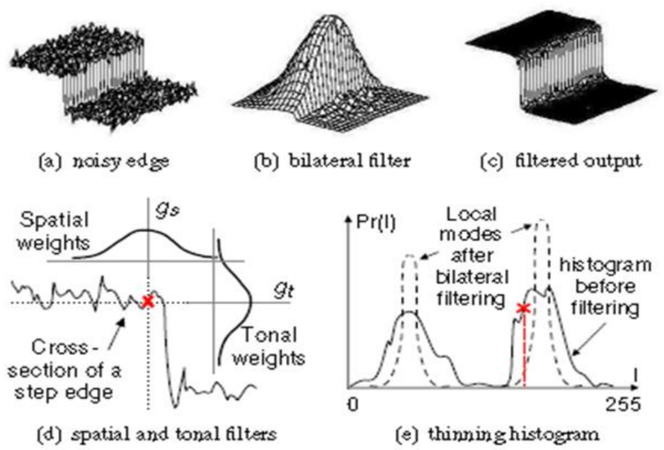

Figure 4. Bilateral filtering as a mode seeking process

where $f(s,s_o) = g_s\,(s - s_o) \,.\, g_t\,(I(s) - I(s_o))$ is the bilateral filter for the neighborhood around s_o. The constituent spatial and tonal weights g_s and g_t are Gaussian functions:

$g_s\,(s) = g(x\,,\sigma_s)\,.\,g(y\,,\sigma_s)$ $g_t\,(I) = g(I\,,\sigma_t)$ (1)

where $g(t, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-t^2/2\sigma^2}$ σ_s and σ_t are the spatial and tonal scales of bilateral filtering.

Figure 4 depicts the formation of a bilateral filter centered at a pixel on one side of a noisy step edge (fig. 4a). The role of the spatial weight g_s is to limit the spatial extend of the filter operation. It accounts for the bell shape of the bilateral filter. The tonal weight g_t suppresses the contributions of pixels from the other side of the edge. It is responsible for the truncation of approximately half of the Gaussian bell (fig. 4b). Since only pixels sharing similar intensity with the current pixel have significant weights in the local analysis, the edge is not diffused across and noise is effectively suppressed (fig. 4c). A compact bi-modal histogram of the filtered edge compared to that of the noisy edge in figure 4e. Further confirms this noise reduction and edge sharpening. As pointed out in [6], bilateral filtering is a first iteration of an iterative local mode finding process. If the bilateral filter is applied several times, the filtered result will eventually converge to a sharp edge transition and the local histogram will reduce to two spikes at the intensity levels on either sides of the edge.

2. Alpha Trimmed Filter

The alpha-trimmed mean filter [5] is widely used for image processing. Here, we use the alpha-trimmed mean for image decomposition. Let X be a finite set of N numbers. The alpha trimmed mean of X is obtained by sorting X into ascending order then sorted set of numbers are trimmed with a fixed fraction $\alpha(0 < \alpha < 0.5)$ from the high and low ends of the sorted set, and remaining values are averaged out. This process is called α-trim filtering.

For an image with size of M x N , let K = M x N and a single index $X_1, X_2, \ldots X_k$ indicate the sorted values of all pixels of the image such that $X_1 \leq X_2 \leq \ldots \leq X_k$. Let $T_\alpha = [\alpha K]$ is the number of the smallest and largest pixel values to be trimmed or discarded from the sorted sequence, X_1 , X_2, … X_k, The alpha-trimmed mean of the image is defined by

$$X_\alpha = \frac{1}{K - 2T_\alpha} \sum_{i=T_\alpha+1}^{K-T_\alpha} x_i$$

where 0 <α < 0.5 is the percentage of the trimmed samples. The alpha-trimmed mean will be different when the parameter a changes. For example, it will be the mean value of the image for α = 0 and the median value of the image if α is close to 0.5. Taking this advantage, we use the alpha-trimmed mean as the threshold for image decomposition.

III. RESULTS AND DISCUSSION

1. Proposed Hybrid Filter

This hybrid filter is the sequential combination of bilateral filter and alpha trimmed filter. When we arrange these filters in different orders, we get the different output . First we remove the salt & pepper noise through alpha trim filter and pass the result to the bilateral filter. The bilateral filter removes the additive gaussian noise from the image. The output is not similar to the original image, but it is almost same.

A hybrid filter is a two pass procedure.

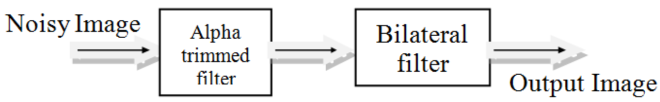

Figure 5. Methodlogy

2. Performance Evaluation Standards

The term MSE (mean square error)[3] is the difference between the original image and the enhanced image and it should be as minimum as possible. The peak signal-to-noise ratio, its abbreviation is PSNR[4], is an scientific term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The Mathematical definition of the PSNR and MSE is following:

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

and

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(Y_{i,j} - S_{i,j})^2$$

3. Simulation Results

The Original Image is tribesman image. Adding two types of Noise (Additive Gaussian noise, Salt & Pepper noise) and pass this image to our hybrid bilateral filter we get the desired result, the result depend upon the intensity of the noise .The mean square error (MSE) & peak signal-to-noise (PSNR) standards are used to make performance comparison between the original image (tribesman.jpg) and the hybrid filter output.

Fig 6.1 Original Image

Figure 6.2 Image With Noise

Figure 6.3 Output Image in Hybrid Filter

Figure 6.4 Output Image in Bilateral Filter

Figure 6.5 Output Image in Alpha Trimmed Filter

We have computed the MSE and PSNR values under different circumstances to evaluate the performance of our filter. The following table shows the MSE & PSNR value with different percentage of salt & pepper (impulse) noise :-

Type of Filter Used In Image Enhancement	**Percentage of Noise**	**Mean Square Error (MSE)**	**Peak Signal to Noise Ratio (PSNR)**
BilateralFilter	0.05	1.32	15.43
Hybrid Filter	0.05	1.20	27.32

Table 6.1

Type of Filter Used In Image **Enhancement**	**Percentage of Noise**	**Mean Square Error (MSE)**	**Peak Signal to Noise Ratio (PSNR)**
BilateralFilter	0.10	1.83	15.49
Hybrid Filter	0.10	1.38	26.72

Table 6.2

Type of Filter Used In Image **Enhancement**	**Percentage of Noise**	**Mean Square Error (MSE)**	**Peak Signal to Noise Ratio (PSNR)**
BilateralFilter	0.15	1.91	15.30
Hybrid Filter	0.15	1.87	25.04

Table 6.3

IV. CONCLUSION

We used the tribesman image in .jpeg format and adding two noises (Impulse noise, Gaussian noise) and apply the noisy image to hybrid bilateral filter. The final enhanced image is depending upon the percentage of the salt & pepper noise. When these variables are less quality of the enhanced image is almost similar to the original image. We can denoise noisy image up to certain percentage depending upon noise level in pixel. The extracted results obviously illustrate the efficiency of the hybrid bilateral filter and give better image quality or at least equal compared to the bilateral filter.

V. FUTURE SCOPE

There are various fields in which scope of improvement is very high like Instead of using the alpha trimmed filter we can use the Adaptive wiener filter. We could also maximize intensity of different types of noises in image either in additive manner or in multiplicative manner.

An expert system can be made that tell us which filter must be used if we encounter specific type of noise in image or which combination of filter must be used if combination or mixture of noise in present.

VI. REFERENCES

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