Parametric Evaluation of Guided Image Filter with Window Size

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Abstract

The guided filter is an explicit image filter that can be procured from a local linear model. The purpose of the guided filter is to reckon the filtering output by taking the subject of a guidance image, which can be either self-image or reference image, into consideration. Similar to a bilateral filter, a guided filter can be operated as a smoothing edge-preserving operator that behaves much efficiently near the edges. Apart from smoothing, new filtering applications such as guided feathering and dehazing can also be enabled as the filter is able to transfer the explicit structure of the guidance image to the filtering output. Another aspect of the guided filter is that it naturally has a rapid and exact algorithm, irrespective of the intensity range and kernel size. The regularization parameter (ϵ) and window size (r) are the two salient aspects which ascertain the characteristics of the guided image applied to the input image i.e the degree of the edges of an image can be discerned with the help of them. In this paper, we will be observing the effect of the window size on a guided filtered image.

Keywords- Image Guided Filter, SSIM, PSNR, Performance Evaluation

1. Introduction and objectives

The guided filter can be considered as a type of filtering process where the filtering output is locally a linear transform of a guidance image or reference image [1]. The guided filter imparts a smoothing effect to an image. Comparable to a bilateral filter [5], the guided filter also maintains edge-preserving smoothing attributes, but very much unlikely to suffer from the gradient reversal artifacts. Image smoothing/enhancement, dehazing & join upsampling, flash/no-flash image, matting/feathering, HDR compression are some of the applications which utilize the guided filter. For high dimensional images as well as grayscale images, it has an O(N) time (in the number of pixels N) non-approximate algorithm which is a very vital feature for real-time applications. The characteristic of the filtering output of a guiding filter depends on two important factors- regularization parameter (ε) and square window of radius (r). The purpose of this paper is to observe the effect of the window size on a guided filtered image.

2. Methods

$$E(a_k,b_k) = \sum_{i \in \omega k} ((a_k I_i + b_k - p_i)^2 + \varepsilon a_k^2)$$

The equation mentioned above is a linear ridge regression model. For the specific equation, **p** can be assumed as the filtering input image, **I** as the guidance image, and **q** as the output image. **i** is the pixel index. P and I are provided in advance depending on the application. Image q can be assumed as a linear transform of I in a window $\boldsymbol{\omega_k}$ centered at pixel **k**. ($\mathbf{a_k}$,$\mathbf{b_k}$) are some linear coefficients assumed to be constant in ω_k. We need constraints from p(filtering input) in order to determine ($\mathbf{a_k}$, $\mathbf{b_k}$). Here, the parameter keeping $\mathbf{a_k}$ in check from being substantially large is the regularization parameter (ε). When I ≡ p, ak = $\sigma^2_k / (\sigma^2_k + \varepsilon)$ and $b_k = (1 - a_k)\mu_k$. So, it is clear that if $\varepsilon = 0$, then $a_k = 1$ and $b_k = 0$. When $\varepsilon > 0$, two cases can be observed-

Case I: 'High variance.' If the image 'I' varies with ω_k, then $\sigma^2_k >> \varepsilon$, so $a_k \approx 1$ and $b_k \approx 0$.

Case II: 'Flat patch.' If the image 'I' remains almost constant with ω_k, then $\sigma^2_k << \varepsilon$, so $a_k \approx 0$ and $b_k \approx \mu_k$.

The patches with variance (σ^2) much larger than regularization parameters ($\sigma^2 >> \varepsilon$) are preserved, whereas the patches with variance(σ^2) much smaller than regularization parameters ($\sigma^2 << \varepsilon$) are smoothed. Similarly, the window plays a significant role for enhancing image quality balancing edge preserving smoothing.

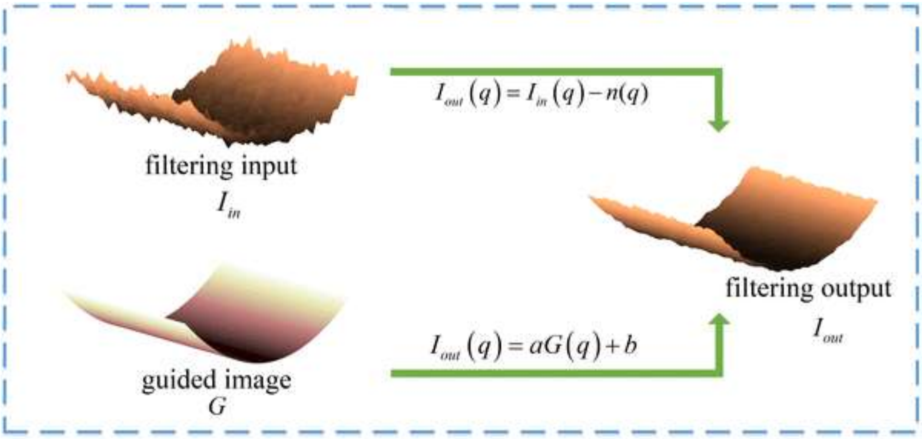

Figure 1. Image Guided Filter Mechanism

3.Results and discussions

For this experiment, we made sure that the regularization parameter (ε) remains exactly the same throughout the procedure which is 0.01, while window r =1,3,5,7,9,11. A mirror image of a figure 'Original' is taken into account which before achieving the credibility to be accepted as the *guidance image* for the experiment has to go through some specific operations. Contemplating radius of square window (r) and constant regularization parameter (ε)=0.01, this guidance image guided the figure. 'Original' to acquire the guided images displayed in the following *qualitative table*. As a result of doing this, the quality of the resulting images could be examined with quantitative assessment as shown in fig. of the *qualitative table* and table of the *quantitative table*. From the result, it is quite evident that the more the prominence of the edges of guided images, the lesser the similarity between the original and guided image, which is observed in the *quantitative table* [6].

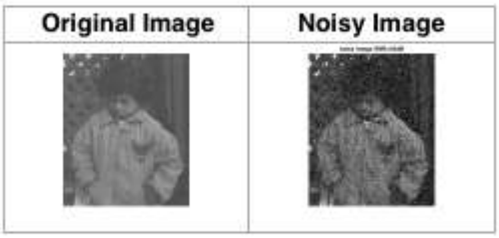

Figure 2. a) Original Image, b) Noisy Image

Performance assessment reveals efficiency, robustness, accuracy, and sensitivity. For this specific work, parameters such as SSIM and PSNR aided in the appraisal of parametric performance. SSIM or the Structural Similarity Index is a perceptual metric that helps in the quantification of image quality degradation caused by processing. PSNR or the Peak Signal-to-Noise Ratio is an expression for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. In the case of the reference image is the same as the input image, SSIM and PSNR are 1 and infinite respectively, whose value diminishes with the surge in the dissimilarities between the two images. As shown in Table 1, SSIM and PSNR change or decrease with the change of window (r).

Figure 3. Recovered Image with window size (1,3,5,7,9,11) L-R with constant regularizing parameter □.

Table I. Performance of Image Guided Filter with the figure 3(Parameters-SSIM, PSNR) [2-4]

Window	1	3	5	7	9	11
SSIM	0.6125	0.9309	0.9237	0.9041	0.8891	0.8788
PSNR	29.9905	38.177	36.8957	35.35	34.2285	33.3594

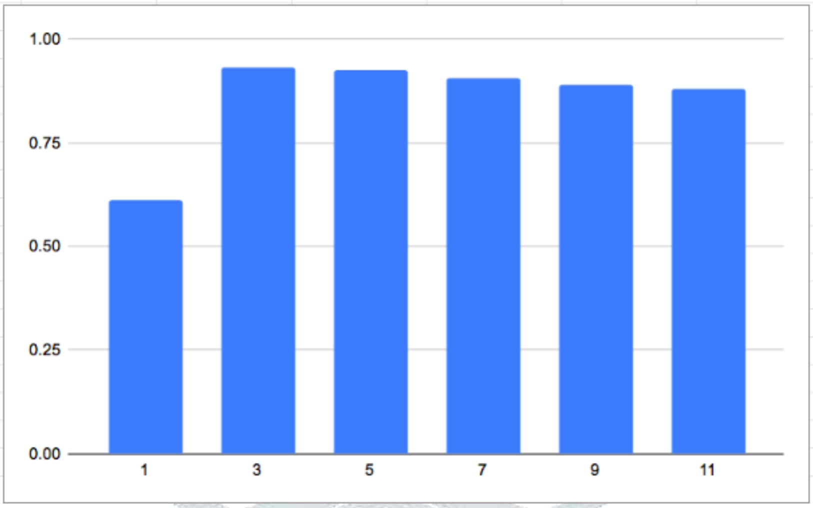

Figure 4. Plotting SSIM vs. Window Size

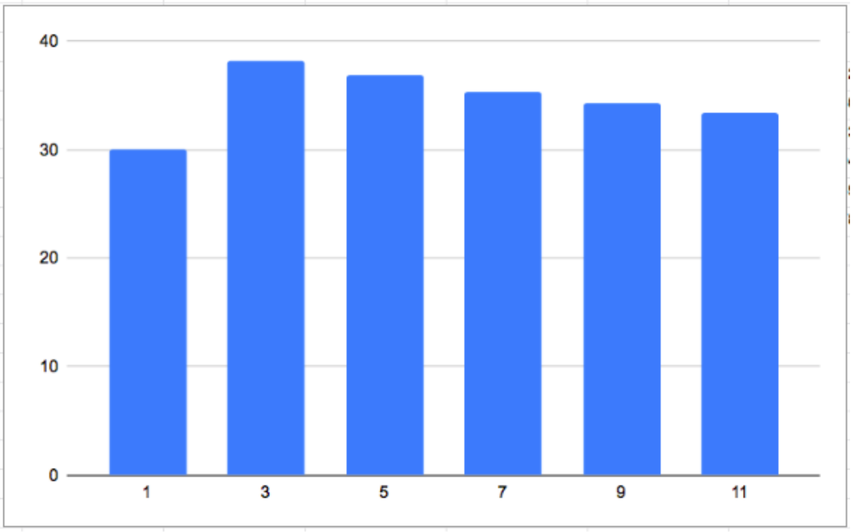

Figure 5. Plotting PSNR vs. Window Size

4.Conclusion

In this paper, we have presented the effect of the regularization parameter in a guided filter. PSNR and SSIM are two functions of MATLAB which, using the encoding process of the filtered image to the original image, determines image quality or loss of quality of the image. With an increment of window size as parameter (r), both PSNR and SSIM increases (1-5) as shown in figure 4 and 5. But PSNR, SSIM decrease onwards. Both of these functions represent human visual perception. In the case of the window size (r) being less or absent, the original image appears to be slightly blurred. On the other hand, with the increase of r, the edges of the image become more sharpened and enhance the image. But in the event where the value of r exceeds a certain limit, the filtered image becomes unpleasant to the human eyes. Optimization is required for better human visual perception and keep that in mind more detailed work is in progress for the near future.

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