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Fast Weighted Guided Image Filter

Seella Krishnaveni[1], Dr. G. Umamaheswara Reddy[2]

M.Tech Student, Department of ECE, S. V. University College of Engineering, Tirupati, India [1]

Associate professor, Department of ECE, S. V. University College of Engineering, Tirupati, India[2]

Abstract: The Weighted guided image filter (WGIF) avoids halo artifacts, which is drawback of Guided image filter (GIF) at a cost of increment on running times. In this paper, a speedup method is included, which can speed up WGIF from O (N) time to O (N/s^2). It can applicable in all applications in which WGIF can be used. Experimental results show that it can produce images with better visual quality comparable to WGIF and we can also observe the decrement on running times.

Keywords: WGIF, GIF, halo artifacts, run time.

I. INTRODUCTION

In different fields such as computational photography, computer vision, computer graphics and image processing require edge preserving smoothing techniques Typical examples include image de-noising [1], [2], fusion of differently exposed images [3], tone mapping of high dynamic range (HDR) images [4], detail enhancement via multi-lighting images [5], texture transfer from a source image to a destination image [6], single image haze removal [7], and etc.

There are two types of edge-preserving image smoothing techniques. One type is global optimization based filters as in [1], [2], [4], and [8]. They can provide better quality but high computational cost. The other type is local filters such as bilateral filter (BF) [9], its extension in gradient domain [10], trilateral filter [11], and their accelerated versions [5], [12], [13] as well as guided image filter (GIF) [14]. Compared with the global optimization based filters, the local filters are generally simpler. However, the local filters cannot preserve sharp edges like the global optimization based filters [4], [14]. As such, halo artifacts are usually produced by the local filters when they are adapted to smooth edges [14]. These halo artifacts can be avoided by using WGIF [16] with an increment in running time when compared to GIF.

In this paper, the technique of improving speed from fast guided image filter (FGIF) [15] is incorporated in to WGIF [16]. This method reduces the time complexity from O(N) to O(N/s2) for a sub sampling ratio s. An actual speedup of greater than ten times (>10*) can be observed. Experimental results show that the resultant algorithms produce images with excellent visual quality as those of global optimization based algorithms, and at the same time the running times of the proposed algorithms are comparable to the FGIF[15] based algorithms.

II. FAST WEIGHTED GUIDED IMAGE FILTER

The WGIF [16] can provide better visual quality, with a run time of O(n) . Though this run time is very less when compared to global filter, we can reduce this run time much less by using this fast weighted guided image filter. Here we are incorporating a speed up method from FGIF [15] in to WGIF.

A. Method

We denote the guidance image, filtering input image, and filtering output image as I, p and q respectively. The guided filter is driven by a local linear model:

$$q_i = a_k I_i + b_k, \text{ for all } i \in w_k, \quad (1)$$

Where i is the index of a pixel, and k is the index of a local square window with a radius r. Given the filtering input image p, minimizing the reconstruction error between p and q gives

$$a_k = \frac{\frac{1}{|w|}\sum_{i \in w_k} I_i p_i - \mu_k \bar{p}_k}{\sigma^2{}_k + \varepsilon}, \quad (2)$$

$$b_k = \bar{p}_k - a_k \mu_k , \quad (3)$$

Where μ_k and σ_k are the mean and variance of I in the window k, and ε is a regularization parameter controlling the degree of smoothness. The filtering output is computed by:

$$q_i = \bar{a}_i I_i + \bar{b}_i, \quad (4)$$

Where $\bar{a}i$ and $\bar{b}_i$ are the average of a and b respectively on the window W_i centered at i. The main computation is a series of box filters. Algorithm shows the pseudo-code of the fast guided filter, where f_{mean} (, r) denotes a mean filter with a radius r. Here s is sub sampling ratio.

B. Algorithm

Input: filtering input image p, guidance image I, radius r, regularization parameter e, sub sampling ratio s ;

Output: filtering output q.

1: $I' = f_{subsample}(I; s)$
$p' = f_{subsample}(p; s)$
$r' = r/s$
2: $mean_I = f_{mean}(I'; r')$
$mean_p = f_{mean}(I'; r')$
$corr_I = f_{mean}(I' .* I'; r')$
$corr_{Ip} = f_{mean}(I' .* p'; r')$
$corr_p = f_{mean}(p' .* p', r')$
3: $var_I = corr_I - mean_I .* mean_I$
$var_p = corr_p - mean_p .* mean_p$
$cov_{Ip} = corr_{Ip} - mean_I .* mean_p$

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4: $\Gamma_p = (var_I + e) / (var_p + e)$
$mean_{\Gamma p} = f_{mean} (\Gamma_{p, r'})$
5: take value for λ
$\epsilon = \lambda / mean_{\Gamma p}$
6: $a = cov_{Ip} ./ (var_I + e)$
$b = mean_p - a.* mean_I$
7: $mean_a = f_{mean} (a, r')$
$mean_b = f_{mean} (b, r')$
8: $mean_a = f_{upsammple} (mean_{a, s})$
$mean_b = f_{upsammple} (mean_{b, s})$
9: $q = mean_a.*I + mean_b$

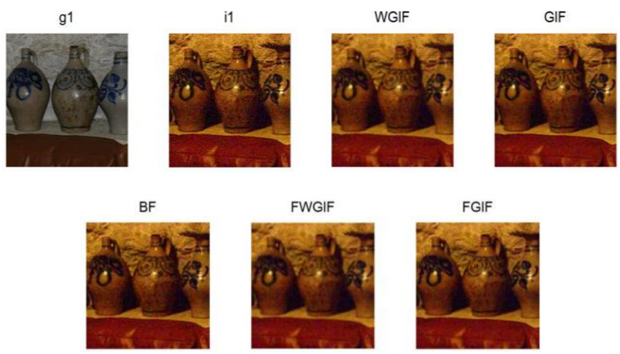
Fast weighted guided image filtering can reduce the run time from O(N) to O(N/s^2) for a sub sampling ratio ‘s’. This speedup method has almost no visible degradation. It can provide better results comparable to weighted guided mage filter. It has all the advantages of WGIF. It can be applicable in all applications where we can use WGIF. Below figures shows some of the applications of fast weighted guided image filter (FWGIF) and are compared with bilateral filter, GIF, FGIF, and WGIF.

(a) (b) (c) (d) (e) (f)

Fig.1. Detail enhancement. The values of ζ1 and λ are 15 and 1/128, respectively. (a, b, c) by the WGIF, (d, e, f) by the FWGIF with the value of θ as 1, 4, and 9, respectively.

(a) (b) (c) (d) (e) (f)

Fig.2. Comparison of enhanced images via different filters.(a) is image to be enhanced, enhanced image by the BF [9] (b), GIF [14] (c), FGIF[15] (d), WGIF[16](e) and FWGIF(f)



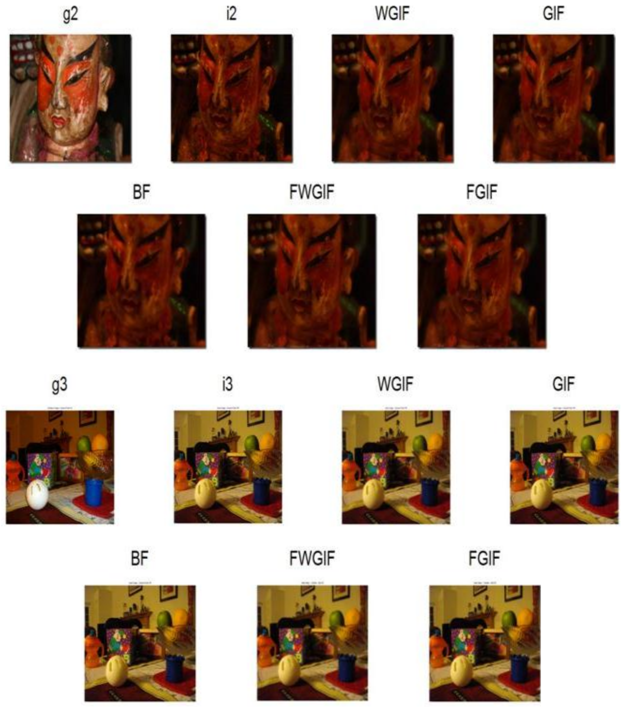


Fig.3. Flash / no-flash denoising. g1, g2, g3 are guidance images, i1, i2, i3 are input images.

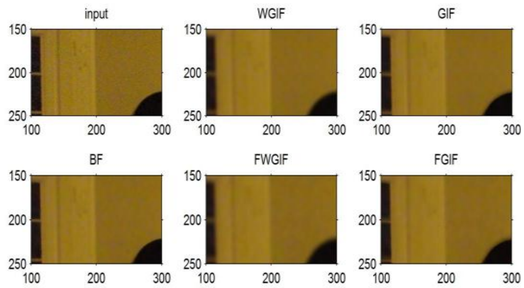


Fig 4. Zoomed in regions of flash/no flash denoising corresponding to images g3 and i3

III. COMPARISON OF DIFFERENT EDGE PRESERVING SMOOTHING TECHNIQUES

Here comparison is done among different edge preserving techniques with respect to parameters such as elapsed times, peak signal to noise ratio (PSNR) and men square error (MSE).

TABLE I: ELAPSED TIMES (IN SEC) FOR THE LISTED TECHNIQUES FOR DIFFERENT IMAGES SHOWN IN FIGURE 3

Filter type	**Elapsed time for image i1**	**Elapsed time for image i2**	**Elapsed time for image i3**
BF	17.069104	4.395412	43.529232
GIF	1.092759	0.099879	2.023700
FGIF	0.165900	0.062779	43.529232
WGIF	1.806152	0.185177	0.950010
FWGIF	0.201493	0.062771	0.661594

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TABLE II PSNR IN DB FOR LISTED TECHNIQUES FOR DIFFERENT IMAGES SHOWN IN FIGURE 3

Filter type	PSNR for image i1	PSNR for image i2	PSNR for image i3
BF	37.67	38.13	38.41
GIF	36.86	37.83	37.82
FGIF	36.75	37.67	37.68
WGIF	36.77	37.36	37.54
FWGIF	36.71	37.27	37.46

TABLE III MSE FOR LISTED TECHNIQUES FOR DIFFERENT IMAGES SHOWN IN FIGURE 3

Filter type	MSE for image i1	MSE for image i2	MSE for image i3
BF	0.0015	0.0005	0.0003
GIF	0.0071	0.0011	0.0011
FGIF	0.0086	0.0032	0.0014
WGIF	0.0082	0.0027	0.0019
FWGIF	0.0100	0.0015	0.0022

IV. CONCLUSION

FWGIF is proposed in this paper by incorporating the technique of speed up from FGIF in to WGIF. With this technique we can get improvement in running times. This method can provide all advantages of WGIF and can be applicable to the applications in which WGIF can be applicable. It can provide a speed up of greater than ten times. Experimental results show that it can provide better visual qualities and PSNR comparable to GIF and FGIF. Due to its simplicity and low running rates it has many applications in the fields of computational photography and image processing

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BIOGRAPHY

Ms. Seella Krishnaveni completed her B.Tech in Electronics & Communication Engineering at Alfa College of Engineering and Technology, Allagadda, Affiliation to JNTUA, Anantapuram, INDIA in 2013. She is pursuing her M.Tech Degree with specialization in Signal Processing (SP) at SVUCE, SV University, Tirupati, INDIA. Her areas of interest include Signal Processing and Communication Systems

Dr. G. Umamaheswara Reddy received B.Tech degree in Electronics and Communication Engineering and M.Tech degree in Instrumentation & Control Systems and obtained Ph.D. from Sri Venkateswara University, Tirupati in 1992, 1995, and 2013 respectively. He is a member in ISTE, IE, and BMSI. Currently, he is working as Associate Professor in the Department of Electronics and Communication Engineering, Sri Venkateswara University, Tirupati, Andhra Pradesh, India