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EDGE AWARE WEIGHTED GUIDED IMAGE FILTERING FRAMEWORK FOR IMAGE ENHANCEMENT, DEHAZING AND IMAGE FUSION

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ABSTRACT:

The general and conventional method of image filtering is filtering with edges but this method suffers from halo artifacts. In this proposed work, the use of aware weighting into an existing Image Guided Filter to sort out the problems such as halo artifacts. The WGIF has the advantage of both methods of filtering such as Global filtering and Local filtering. WGIF has many advantage as compared with conventional Guided Image Filter.

Other advantages are, the WGIF removes halo artifacts in the same ways as that of the conventional Global filters and complexity of the WGIF is same as that of Guided Image Filtering. The WGIF can be applied for single image dehazing, single image detail enhancement and dehazing. This WGIF produce images with better visual quality, better color contrast and fidelity. Experimental results prove that the resultant algorithms can give images with better visual quality at the same time other artifacts can be removed. In future, this idea can be adapted for improvement of anisotropic diffusion and Poissons image editing[9].

KEYWORDS : Haze removal, exposure fusion, weighted guided image filtering, detail enhancement, edge aware weighting, halo artifacts.

I. INTRODUCTION:

Image processing is now becoming very important and essential tool in all disciplines of engineering and technology. In human visual perception, edges gives an effective stimulation which important for neural interpretation. When these are properly seen then only correct interpretation can be made.

There are many conventional methods of image filtering that provides good visual quality but they also have some drawbacks and limitations. To overcome these drawbacks and limitations, a new technique is introduced which is based on preservation of edges. This techniques nothing but the Weighted Guided Image Filtering. In this technique, conventional guided filter is associated with the edge preserving technique.

In smoothing process, generally an image is decomposed into two layers : a base layer and a detail layer. The processing method of removing noise can be divided into frequency domain and spatial domain[3].

There are two types of edge aware filtering : Global optimization based filter and another is bilateral filter. In global optimization based filters, the performance criteria consists of a data term and a regularization term where local filters are consisting of bilateral, trilateral and gradient filters.

In Weighted Guided Image Filtering, edges play very crucial role in vision and contains huge amount of information. After applying this techniques, edges of the image are preserved and adjusted for detail enhancement and god visual clarity.

II. EXISTING METHODS:

While dealing with smoothing and edge preserving techniques, one must consider conventional and existing methods of filtering. These method include bilateral filter, adaptive bilateral filter, trilateral filter, non average filter, real time edge preserving filter, guided image filter, adaptive guided image filter, image smoothing via L_0 gradient minimization[4],[5]. Among them, following are explained in brief for better understanding of WGIF.

1. BILATERAL FILTER

Bilateral filter is the simplest filter and non iterative that computes the filtering output at each pixel as the average of near-by pixels, weighted by the Gaussian of both range and spatial distance. Bilateral filter preserves edges same as that of human visual perception.

In bilateral filtering, a low pass filter is applied and then the value of a pixel is replaced by an average and similar nearby pixel values. But efficiency was another problem for bilateral filters[11].

Suppose, a low pass filter is applied to image f(x) which produces output image,

$$h(x) = k_d^{-1}(x) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(\xi)\, c(\xi, x) dx \qquad (1)$$

where, c(ξ,x) denotes the geometric closeness between nearby centre x and neighborhood point ξ. The range filter is defined as,

$$h(x) = k_r^{-1}(x) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(\xi) s[f(\xi), f(x)] d\xi \qquad (2)$$

where, function 's' operates in the range of the image function 'f' . Then, combined filtering is defined as,

$$h(x) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(\xi)\ c(\xi, x)\ s[f(\xi), f(x)]\ dx \qquad (3)$$

with the normalization,

$$k(x) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} c(\xi, x)\ s[f(\xi), f(x)]d\xi \qquad (4)$$

This combined filter in equation (5) is called as bilateral filter.

2. NON AVERAGE FILTERS:

Non average filters are primitive type edge preserving filters. The median filter was a well known filter and is a special case of local histogram filter. Histogram filters had O(N) time implementations same as that of bilateral grid.

3. GUIDED IMAGE FILTERS:

Conventional methods of filtering include Linear Translation Invariant such as Gaussian, Laplacian and Sobel filters[7]. It involves a guidance image, filtering input image and output image. And hence it is widely used in advanced filtering techniques. Consider, a guidance image I, an filtering input image p, and an output image q. The filtering output at a pixel I is expressed as weighted average is given as :

$$qi = \Sigma j\ W_{ij}(I)\ pj \qquad (5)$$

where i and j are pixel indices and W_{ij} is a function of guidance image I. Guided Image Filter has better edge preserving properties and does not involve reverse gradient artifacts.

4. ADAPTIVE IMAGE GUIDED FILTER:

Sharpness improvement and noise reduction plays an important role in computer vision and image processing. Adaptive Guided Image Filter removes halo artifacts and reduces the noise present in the image. Adaptive guided filter is combination of Guided Image Filter and shift variant technique which is a part of adaptive bilateral filtering[12].

III. METHODOLOGY

Weighted Guided Image Filtering (WGIF) is the combination of edge aware weighting technique and Guided Image Filter. Therefore, before proceeding to WGIF, the edge aware technique must be explained.

1. EDGE AWARE TECHNIQUE:

Consider, a guidance image G, let $\sigma^2_{G,1}(p')$ be the variance of G in the 3×3 windows. An edge-aware weighting $\Gamma_G(p')$ is given by using local variance of 3×3 windows of all pixels and is given as following :

$$\Gamma_G(p') = \frac{1}{N}\sum_{p=1}^{N} \frac{\sigma^2_{G,1}(p')+\varepsilon}{\sigma^2_{G,1}(p)+\varepsilon} \qquad (6)$$

where ε is a small constant and its value is selected as $(0.001\times l)^2$ while L is the dynamic range of the input image. All pixels in the guidance image are used in the computation of $\Gamma_G(p')$. In addition, the weighting $\Gamma_G(p')$ measures the importance of pixel p' with respect to the whole guidance image[8].

(a) Input image

(b)

(b) Edge of input image Figure 1 : Edge aware weighting

By applying edge aware weighting, there is possibility of presence of blocking artifacts in the finale image. To avoid these blocking artifacts, the value of $\Gamma G(p')$ must be filtered by Gaussian filter. The figure (a) shows the input image on which edge aware filter is to be applied and figure (b) shows edge of input image.

The GIF can be improved by incorporating these edge-aware weighting which ultimately called as Weighted Guided Image Filtering. The proposed weighting in equation (6) is used as an example to implement WGIF.

2. PROPOSED FILTER

Same as the GIF , the key assumption of the WGIF is a local linear model between the guidance image G and the filtering output $\hat{Z}$.

$$E = \sum_{p \in \Omega_{\zeta 1}(p')} [(a_{p'} G_{(p)} + b_{p'} - X(p))^2 + \frac{\lambda}{\Gamma_G(p')} a^2_{p'}] \qquad (7)$$

where, $a_{p'}$ and $b_{p'}$ are two constants in the window of $\Omega_{\zeta 1}$ (p) and computed as,

$$a_{p'} = \frac{\mu_{G \odot X,\zeta 1}(p') - \mu_{G,\zeta 1}(p')\mu_{X,\zeta 1}(p')}{\sigma^2_{G,\zeta 1}(p') + \frac{\lambda}{\Gamma_G(p')}} \qquad (8)$$

$$b_{p'} = \mu_{X,\zeta 1}(p') - a_{p'}\ \mu_{G,\zeta 1}(p') \qquad (9)$$

The model ensures that the output has an edge only if the guidance image G has an edge. This proposed filter preserves edges for betterment of clear vision with minimum processing speed. For easy analysis, the images X and G are assumed to be the same. Consider, the case that the pixel p' is at an edge. The value of $\Gamma_X(p)$ is usually much larger than 1. $a_{p'}$ in the WGIF is closer to 1 than $a_{p'}$ in the GIF. This implies that sharp edges are preserved better by the WGIF than the GIF.

IV. APPLICATIONS:

Weighted Guided Image Filtering can become a very helpful tool in the field of image processing. Applications of WGIF with experimental results are given below. All these algorithms can be implemented in MATLAB.

1. IMAGE ENHANCEMENT:

When the issue of image enhancement is concerned, the basic step is decomposition of into two components or layers. These layers are : a basic layer and a detail layer[13]. These layers are nothing but components of that image given as,

$$Z_{enh}(p) = X(p) + \theta_e(p), \quad (10)$$

where, $\theta(>0)$ is a positive constant and it is called an amplification factor. As this filtering method mainly focuses on edge aware and weighting technique, one of weighting computation technique is described in equation(6).

This technique gives clear and appropriate sharp edges which ultimately leads to the detail enhancement of the image. With the proposed filter for detail enhancement fine details in all areas except flat ones are enhanced. The visual quality of the final enhanced image can be improved.

2. DEHAZING:

Dehazing is also achieved by weighting technique in which haze, fog and smoke is removed. Due to this haze, image loses its contrast and color fidelity. The model that describes the formulation of a haze image is given as,

$$X_c(p)=\hat{Z}_c(p)t(p)+A_c(1-t(p)) \quad (11)$$

where 'c' belongs to {r,g,b} color channel, X_c is the observed density, $\hat{Z}_c$ is the scene radiance, A_c is the global atmospheric light and t is the medium transmission describing the portion of the light that is not scattered and reaches the camera . The term in the equation $\hat{Z}_c(p)\ t(p)$ denotes scene radiance.

3. IMAGE FUSION:

Conventional technologies of digital image processing and image filtering have some drawbacks related with LDR and HDR images. This drawback can be overcame by capturing LDR images at different exposure angles. Image fusion is done by collecting information from these differently exposed images[2],[11].

Suppose, input image on which the filter is to be applied is denoted as X_k $(1 \le k \le L)$ and their luminance components denoted as Y_k $(1 \le k \le L)$. The value of G(p') is computed by using all luminance components Y_k $(1 \le k \le L)$ in log domain. Let, $\sigma^2 \log(Y_k),1(p')$ be the local variance of $\log(Y_k)$ in the square window of 3×3 centered at the pixel p'. σ is the overall local variance. the weighting function $\gamma(z)$ is defined as follows :

$$\gamma(z) = z + 1; \quad \text{if } z \le 127$$
$$\gamma(z) = 256 - z; \text{ otherwise}$$

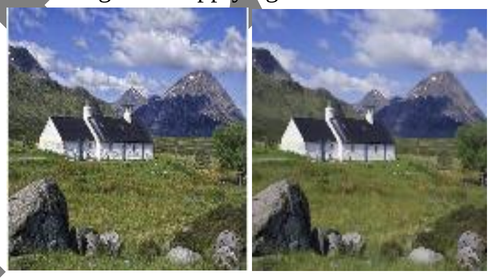
Halo artifacts present in the image due to GIF are avoided by WGIF and color contrast is also maintained.

V. EXPERIMENTAL RESULTS:

This section gives the experimental results of above methodology.

1. IMAGE ENHANCEMENT:

Figure 2 shows results obtained by applying proposed methodology of weighting. The image (a) is the input image on which WGIF is to be applied and (b) shows the resultant image after applying WGIF.



(a) (b)

Figure 2 : Results of Image enhancement algorithm

2. DEHAZING:

WGIF for dehazing remobes halo artifacts caused due to Guided Image Filte. In dehazing process, the scattered light is eliminated to increase scene visibility and recover haze-free scene contrast. In dehazing technique, a similar principle is used to estimate the color of the haze. Image dehazing is a difficult problem and most of the papers addressing it assume some form additional dataon top of the degraded photograph itself.

Following figures show the resultant images after applying dehazing algorithm.

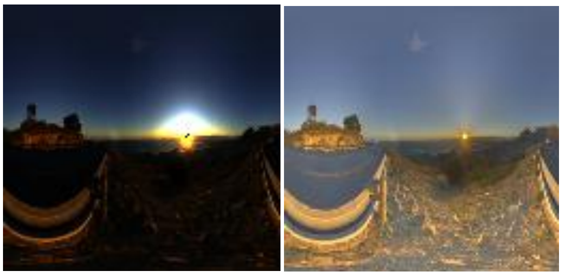
(a) (b)

Figure 3 : Results of Dehazing algorithms

Proposed dehazing algorithm removes halo artifacts caused by GIF and maintains color fidelity which is clealry.

3. IMAGE FUSION:

The visual quality of the fused images by the WGIF is comparatively good as that of the fused images by the global optimization based approach. Following are the results of image fusion weighted guided filtering technique. Image (a) is the input image and image (b) is the output image for image fusion algorithm.



(a) (b)

Figure 4 : Resultant images of image fusion by WGIF

VI. CONCLUSION:

In this paper, Weighted Guided Image Filter framework for different applications such as single image detail enhancement, haze removal, image fusion of differently exposed images with experimental results is explained in brief. WGIF preserves sharpe edges and filters them for better vision[8]. WGIF has less calculation due to its advanced algorithm. WGIF gives better results as compared with conventional type of image filtering methods such as bilateral filters and grids, trilateral filters, guided image filters, adaptive guided image filters[4],[5],[10].

This reduces the complexity and increases the speed of processing. Due to these advantages, it is can be used in various fields such as medical image processing, computational photography[1]. It is important to note that the WGIF can also be adopted to design a fast local tone mapping algorithm for high dynamic range images, joint upsampling, flash/no-flash de-noising.

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