GUIDED FILTERING WITH VISIBILITY RESTORATION

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Abstract—The image may be corrupted by random variations in intensity, variations in illumination, poor contrast that must be dealt with in the early stages of vision processing. Edgepreserving smoothing is an image processing technique that smooth away textures whilst retaining sharp edges. In this research work we design and implement guided image filter to reduce noise from images. A new technique will be proposed that will integrate the guided image filter with visibility restoration technique.

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I. INTRODUCTION

A. Image Filtering

When an image is acquired by a camera or other imaging system, often the vision system for which it is intended is unable to use it directly. The image may be corrupted by random variations in intensity, variations in illumination, or poor contrast that must be dealt with in the early stages of vision processing. Images are often corrupted by random variations in intensity, illumination, or have poor contrast and cant be used directly. Filtering: transform pixel intensity values to reveal certain image characteristics.

1) Enhancement : improves contrast

2) Smoothing: remove noises

B. Image Degradation

Noise

Images are corrupted by random variations in intensity values called noise due to non-perfect camera acquisition or environmental conditions. Common Types of Noise

Salt and pepper noise: random occurrences of both black
and white intensity values Impulse noise: random occurrences of white intensity values Gaussian noise: impulse noise but its intensity values are drawn from a Gaussian distribution

_ Improper focusing

_ Relative Object camera motion

_ Atmospheric turbulence

– Haze

– Fog

C. Mathematical modeling

For efficient image restoration we must have efficient mathematical modeling .In order to apply mathematical ordering you have to apply number of linearity Too many variables number of factors .Doing accurate mathematical ordering is very difficult in such cases we do.Again you do some amount of approximation minimization optimization

_ Appropriate degradation modelling

_ realization of filters correct for those degradation

D. Edge-preserving

Edge-preserving smoothing [1] is an image processing technique

that smooth away textures whilst retaining sharp edges.Examples are the Bilateral filter. When we need to preserve edge information and at the same time preserve the edges.Even when uniform smoothing does not remove the boundaries,it does distort them. This is not acceptable in the context of, for example, medical imaging. Noise, which is present in every real world image, hampers manual interpretation by human experts as well as automatic segmentation and analysis by computers. Therefore many image processing techniques are developed to reduce noise. The Wiener filter is the best linear filter but requires a priori knowledge of the spectrum of the noise-free image as well as the spectrum of the noise.Noise in domains without texture can simple be reduced by isotropic smoothing, where the spatial size of the smoothing operator determines the amount of noise reduction. So the size or scale of the domain constitutes the limit to this amount. To optimize the global noise reduction, scale adaptive smoothing can be used. In an oriented texture domain or along individual lines and edges, the noise level can be reduced by applying elongated smoothing operators that adapt to the local orientation.

This requires a robust and continuous representation of orientation . Since many natural images can be describedas a collection of grey value and oriented texture domains,a scale and orientation adaptive smoothing scheme provides a powerful noise reduction method. Such a scheme can be realized in different ways, i.e. by anisotropic diffusion .Edges between domains are important features for the interpretation of images. However, smoothing operators tend to blur the edges or borders between the different domains. Therefore a filter should be used that reduces the noise but does not degrade the edges, i.e. an edge preserving filter. In a mosaic of domains characterized by grey value, the borders between the domains are characterized by the difference in grey value.This difference can directly be measured in the image.

E. Visibility Restoration

The widely adopted model for the formation of image in

presence of haze or fog is as follows

Additional assumptions or priors need to be introduced to

solve it. We follow the filtering based method and the additional (assumptions and priors) are hereby described explicitly as follows.

$I_p = J_p t_p + A(1 - t_p)$ (1)

where I is the haze image, J is the scene radiance (the actual appearance of the scene without haze), A is the atmospheric light (commonly assumed as a global constant),t_p is the medium transmission function depending on the scene depth.

When the image is represented as a RGB three channels color image,I_p , J_p , and A are vectors and t_p is a scalar.

The physical process of this equation can be described as follows: the actual radiance J_p at a point p in the scene,is attenuated by the atmosphere when passing throughthe haze, and shifted by an effect of atmospheric light A which is accumulated when the radiance passing through the haze.The first term J_p describes the direct attenuation of scene radiance, while the second term A(1- t_p) describes the effect of atmospheric light and is commonly called air light.[2].

- The dark channel of the haze image I is a rough estimation of term $(1 - t_p)$ in equation (1).
- The depth of scene objects in an image varies smoothly except over large depth jumps.
- All RGB color images have been white balanced, which implies that the atmospheric light A can be simply set to (1, 1, 1).

1) Recovering the Scene Radiance: [3] From thetransmission map and the atmospheric light, we can recover the scene radiance according to (1) given by

$$J(p) = \frac{I(p) - A}{\max(r(p), r\_0)} + A \quad (2)$$

where r_0 is a user-specified constant. In the experiments, we fix this value to 0.1. Fig 3(b) shows recovered scene radiance from (2)

F. Types of filtering

1) Median filters: The main problem with local averaging operations is that they tend to blur sharp discontinuities in

intensity values in an image. An alternative approach is to

replace each pixel value with the median of the gray values in the local neighborhood . Filters using this technique are called median filters[4]. Median filters are very effective in removing salt and pepper and impulse noise while retaining image details because they do not depend on values which are significantly different from typical values in the neighbourhood . Median filters work in successive image windows in a fashion similar to linear filters. However, the process is no longer a weighted sum. For example, take a 3 x 3 window and compute the median of the pixels in each window centered around [i,j].

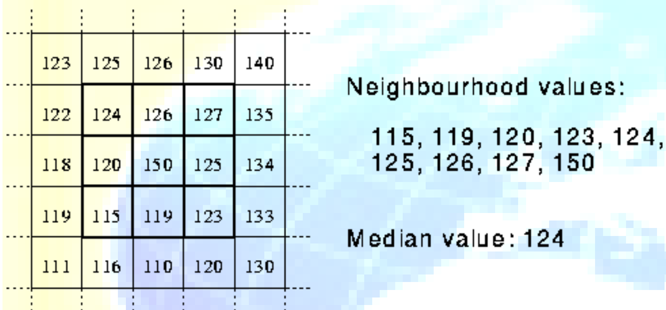


Fig. 1: shows the median value (adapted from [4])

Very effective in removing salt and pepper or impulsivenoise while preserving image detail Disadvantages: computational complexity, non linear filter.

The results of a linear smoothing filter on an image corrupted by Gaussian noise. Left: Noisy image. Right: Smoothed image.

- Sort the pixels into ascending order by gray level.
- Select the value of the middle pixel as the new value for pixel [i,j].

This process is illustrated in Figure . In general, an odd-size

neighborhood is used for calculating the median. However, if the number of pixels is even, the median is taken as the average of the middle two pixels after sorting. In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal. The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise Median filtering is one kind of smoothing technique, as is linear Gaussian filtering. All smoothing techniques are effective at removing noise in smooth patches or smooth regions of a signal, but adversely affect edges. Often though, at the same time as reducing the noise in a signal, it is important to preserve the edges. Edges are of critical importance to the visual appearance of images, for example. For small to moderate levels of (Gaussian) noise, the median filter is demonstrably better than Gaussian blur at removing noise whilst preserving edges for a given, fixed window size. However, its performance is not that much better than Gaussian blur for high levels of noise, whereas, for speckle noise and salt and pepper noise (impulsive noise), it isparticularly effective. Because of this, median filtering is very widely used in digital image processing.

2) Bilateral filter: A bilateral filter [5] is non-linear, edgepreserving and noise-reducing smoothing filter. The intensity value at each pixel in an image is replaced by a weighted average of intensity values from nearby pixels. This weight can be based on a Gaussian distribution. Crucially, the weights depend not only on Euclidean distance of pixels, but also on the radiometric differences. For example, the range difference such as color intensity, depth distance, etc. This preserves sharp edges by systematically looping through each pixel and adjusting weights to the adjacent pixels accordingly.A bilateral filter performs smoothing. Basically, it goes through each pixel and recalculates the pixels value based on the values around it. It does this in a window around the pixel.The amount used from different pixels are weighted, so that some contribute more and some less. The pixels that are closest to the center of the filter and are similar to the center depth value receive a higher weight.

Fig. 2: shows an image that has had bilateral filtering applied to it (adapted from [6])

Of course, the above example 4. But, you get the point. It

smooths out the differences between pixels. This has the effect of reducing some clarity, but in exchange it removes a lot of errors, which is what we need when the image is noisy.An important feature of bilateral filters is that they preserve sharp edges because it will not smooth as much between pixels that have large differences.

(3)Guided filtering : A novel explicit image filter called guided filter [7]. Derived from a local linear model, the guided filter computes the filtering output by considering the content of a guidance image, which can be the input image itself or another different image. The guided filter can be used as an edge-preserving smoothing operator like the popular bilateral filter, but it has better behaviours near edges. The guided filter is also a more generic concept beyond smoothing: It can transfer the structures of the guidance image to the filtering output, enabling new filtering applications like dehazing and guided feathering. Moreover, the guided filter naturally has a fast and nonapproximate linear time algorithm, regardless of the kernel size and the intensity range. Currently, it is one of the fastest edge-preserving filters. Experiments show that the guided filter is both effective and efficient in a great variety of computer vision and computer graphics applications, including edge-aware smoothing, detail enhancement, HDR compression, image matting feathering, dehazing, joint up sampling, etc. Dynamic weather conditions, such as rain and snow, degrade the performance of vision algorithms, which is served for video surveillance and analysis tasks. Many methods have been proposed to reduce the effects of raindrops and snow flakes that are regarded as noises in each frame of a certain video. However, the removing of rain-drop or snow-flake is quite challenging since each of them affects only on a very small region of an image, thus, leading us a rub to determine which region should be smoothed and which should not. A guided filter, by which no pixel-based statistical information for detecting rain and snow are needed, is introduced in the removal stage.

In theory, the guided filter assumes that the filtering output O is a linear transformation of the guidance image I in a local window wk centered at pixel k

$$O_i = a_k I_i + b_k \; \forall_i \in w_k \qquad (3)$$

where w_k is a square window of size (2r+1)(2r+1). The linear coefficients a_k and b_k are constant in w_k and can be estimated by minimizing the squared difference between the output image O and the input image P.

$$E(a_k, b_k) = \sum_{\{i \in w_k\}} \left(\left(a_k I_i + b_k - P_i \right)^2 + \epsilon a_k^2 \right) \qquad (4)$$

where ϵ is a regularization parameter given by the user.The coefficients a_k and b_k be directly solved by linear regression as follows

$$a_k = \frac{\frac{1}{w} \sum_{\{i \in w_k\}} I_i P_i - \mu_k \overline{P_k}}{\delta_k + \epsilon} \qquad (5)$$

$$b_k = \overline{P_k} - a_k \mu_k \qquad (6)$$

where $_k$ and $\boldsymbol{\delta}_k$ are the mean and variance of I in w_k respectively, w is the number of pixels in w_k, and P_k is the mean of P in w_k. Next, the output image can be calculated according to (3). As shown in Fig. 1, all local windows centered at pixel k in the window w_i will contain pixel i. So, the value of O_i in (1) will change when it is computed in different windows w_k. To solve this problem, all the possible values of coefficients a_k and b_k are first averaged. Then, the filtering output is estimated as follows:

$$O_i = \overline{a_i} I_i + \overline{b_i} \qquad (7)$$

Where $\overline{a_i} = \frac{1}{w} \sum_{\{k \in w_i\}} a_k$, $\overline{b_i} = \frac{1}{w} \sum_{\{k \in w_i\}} b_k$.

4) Filtering-based Visibility Restoration:

Tarels algorithm[8] , they first calculate the minimum color components W of the input image I by

$$W_p = \min_{c\in(r,g,b)}\left(I_p^2\right) \quad (8)$$

where p is the location of each pixel in the image. Then they perform the following filtering on W to get B:

$$\mathrm{A} = \mathrm{guided}(\mathrm{W}) \quad (9)$$

$$\mathrm{B} = \mathrm{A} - \mathrm{guided}(|\mathrm{W} - \mathrm{A}|) \quad (10)$$

B is used to estimate the transmission map $\widetilde{t_p}$ by

$$\widetilde{\mathrm{t_p}} = 1 - \min(\epsilon.\mathrm{B_p}, \mathrm{W_p}) \quad (11)$$

where the factor _ in [0, 1] is to control the strength of the restoration. Finally, each channel Jc of the restored image J can be calculated by

$$\mathrm{J_p^c} = 1 - \frac{(1-\mathrm{I_p^c})}{\widetilde{\mathrm{t_p}}} \quad (12)$$

where c ∊ r, g, b for RGB images. A followed post-processing step of tone mapping is suggested [3] to make the color look similar to the input image. Due to the twice median filtering (equation (9) and (10)) employed in Tarels algorithm, it cannot remove haze near large depth jumps in the scene. On the other hand, bilateral filter can better preserve object boundaries when a small σ_R is used[10], but most of the textures are also kept thus it cannot provide enough texture smoothing in the visibility restoration algorithm. More aggressive smoothing can be achieved by increasing σ_R, but the increasing σ_R reduces the ability of the bilateral filter to preserve edges and some of the edges become blurred, as evident from Figure 3 (d). By employing our filtering framework, we modify the processing steps of visibility restoration as follows

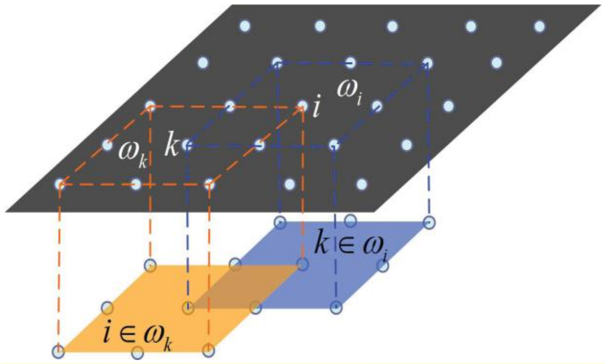


Fig. 3: Illustration of window choice(adapted from [2])

- Calculate W using equation(8)
- Get B by filtering W using our framework;(10)
- Estimate ~t using equation(11)
- Calculate J using equation(12)

G. Quality Metrics

Quality of an image is a characteristic of an image that best measures the perceived image degradation. Quantitative metrics are quantitative measures that automatically predict theperceived image quality. Commonly used quantitative metrics are described below. Quality of the images resulted by various filters can be compared and measured by Edge Preservation Index metric below

1) MSE

2) PSNR

3) Maximum- Difference

4) Mean- Difference

5) Edge Preservation Index(EPI)

II. PROPOSED WORK

A. Problem statement

1) The visibility restoration has been done by using the bilateral filter. The objective of using edge-preserving filtering in the visibility restoration algorithm is to smooth
textured regions while preserving large scene depth discontinuities. Two popular edge-preserving filtering methods are median filtering and bilateral filtering. Unfortunately,both filtering methods cannot work well in visibility restoration. Median filter has strong smoothing ability but can blur edges, while bilateral filter with small range variance cannot achieve enough smoothing on textured regions in the visibility restoration algorithm and that with large range variance will also blur edges .

2) A new image filtering performance known as guided image filter. So this dissertation proposed a new technique
which will incorporate the guided image filter with visibility restoration technique.

3) Reasons for integrating guided image filter with visibility
restoration technique.Because in the most of existing work restoration is done by using bilateral and median filter. But Guided filter has proved to be quite effective than bilateral and median filter in edge preserving. So the integrated technique is seems to be justified as if the visibility restoration using bilateral filter providing better result; therefore image restoration with guided filter will be more effective as guided has proved to accurate than the bilateral filter.

Fig. 4: Original image

4) Therefore the overall objective of this work is to integrate

visibility restoration with guided filtering to improve the accuracy of the restoration. To achieve the objectives we will use MATLAB tool with image processing toolbox. The comparison among proposed integrated technique will also be made with some well known techniques based upon image quality parameters.

Fig. 5: Comparison of guided image filter and bilateral filter

(adapted from [9])

(a) guided filtering

(b) bilateral filtering

(c) guided image

(d) bilateral image

B. Objectives of the dissertation

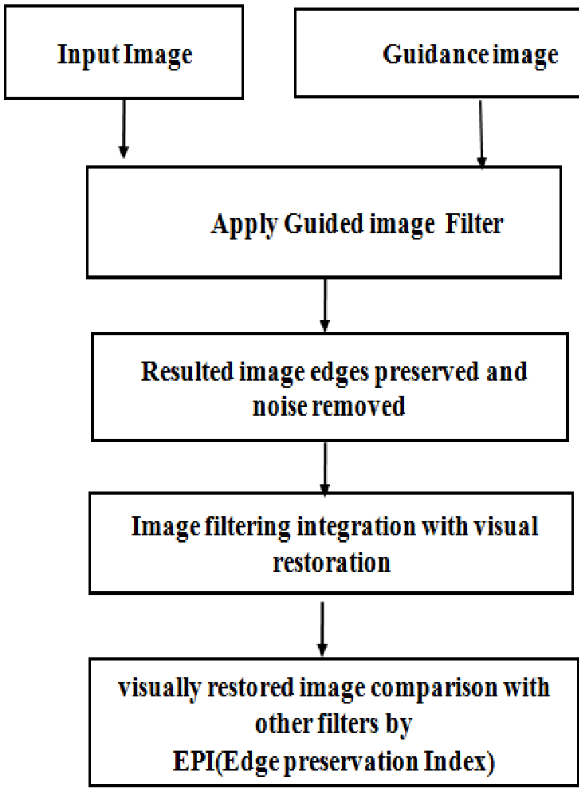
1) The main objective of this dissertation is to design and implement guided image filter to reduce noise from images.

2) A new technique will be proposed that will integrate the guided image filter with visibility restoration technique

3) The design and implementation of the proposed algorithm will be done in MATLAB with image processing toolbox.

4) The comparison among proposed integrated technique will also be made with some well known techniques based upon different image quality parameters.

C. Methodology



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III. 1 Experimental Results

a) Original

b) Median

c) Visibility restored bilateral image

d) Visibility restored guided image

2 Performance analysis

2.1 table 1

This section contains the cross validation between existing and proposed techniques. Some well-known edge preserving filter have been selected to prove that the performance of the proposed filter with visual restoration is quite better than the existing methods.

Edge Preserving Index

Tested Images	Median filter	Bilateral filter	Guided filter
Image 1	0.9738	0.9755	0.9832
Image 2	0.9914	0.9872	0.9918
Image 3	0.9124	0.9764	0.9808
Image 4	0.9895	0.9830	0.9897
Image 5	0.9451	0.9745	0.9929
Image 6	0.9328	0.9785	0.9939
Image 8	0.9409	0.9614	0.9843
Image 9	0.9737	0.9747	0.9927

Table 1: Edge Preserving Index values

From table 1 it is accurately concluded that the visibility restoration with guided filter gives the best result compared to other filters whose (EPI) value in almost all cases is close to 1 that is our filter is correctly improved the image with visibility restoration.

IV. CONCLUSION

This work has reviewed integrating guided image filter with visibility restoration technique.Because in the most of existing work restoration is done by using bilateral and median filter. But Guided filter has proved to be quite effective than bilateral and median filter in edge preserving. So the integrated technique is seems to be justified as if the visibility restoration using bilateral filter providing better result; therefore image restoration with guided filter will be more effective as guided has proved to accurate than the bilateral filter.

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