

Image Dehazing (Defogging) by using Depth Estimation and Fusion with Guided Filter

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ABSTRACT

The season affects the imaging of the hill station highly and all other reasons moreover time to time. Our universal defogging method that determining the atmospheric light and produces a spread map in the YCbCr color channels. With this relative depth information we can construct the corresponding atmospheric light to restrain the edge halation. We generate the spread map by estimating the atmospheric light except a continuous region which has no edge information. The method performs a per-pixel manipulation, which is straightforward to implement and then apply the Guided filter to improve the image quality. The experimental results demonstrate that the method yields results comparative to and even better than the more complex state-of-the-art techniques, having the advantage of being appropriate for real-time applications.

Keywords

Image Fusion, Image Defogging, Scattering model, single image defogging

1. INTRODUCTION

Haze is an annoying factor when it shows up in the image since it causes poor visibility. This is the major problem of some applications in the field of computer vision, such as surveillance, object recognition, etc. Zhen et al. [2] combined the bilateral filter and the adaptive median filter for clear dark channel on image edges. The physical model of algorithm for foggy images is to estimate transmission. It provides the reliability for outdoor visual systems in foggy climate. Wang et al. [3] proposed a multi values depth fusion (MDF) for recovery of fog using local Markov regularization via single foggy image. The fog priors are fused in the inhomogeneous Laplacian IL-MRF adaptively from multiscale filtering. The depth map estimation is a reiterative process with optimization of two variables in adaptive truncated Laplacian (ATL) potential: a base potential variable to regularize smoothness and a line field variable for adaptive control. In 2014 Kawarabuki et al. [4] presented the snowfall estimation from falling snow grains measurement quality that extracted the difference in present defogged image and image background produced by the median. It recognizes the degree of snowfall automatically even in the low visibility by fog. In 2015 Zhao et al. [5] removed the fog by Image defogging (IDF) method that influences from the fogs in an image to improve its quality. For the single scattering of light dominated pixels the single scattering physics model is used in the hybrid model and for the remaining pixels the multiple scattering physics model (MSPM) is used.

[7] In this paper, we propose a new transmission model using LO norm for image fog removal. In the prior work, the bilateral filter was used to reduce the halo artifacts. However, it is only a local optimization. Hence, we observe non-zero gradients to develop the gradient smoothing method for global

control. The proposed model then locates significant edges to highlight the prominent parts of an image. Experimental results show the effectiveness of the proposed model for defogging [7]. The theoretical background can be discussed in terms of the basic image features and the image properties [8-18]. [19] Image has important applications in many fields such as marine surveillance, environment monitoring and so on. The scattering effects of the atmospheric particles in the air play a main role of resulting in contrast reduction and color fading. For dealing with this challenging but imperative issue, there are numerous researchers have strove for this scientific field and published a plenty of findings about restoring the foggy image. In this paper, we summarized the existing outcomes and reviewed the approaches which were employed for defogging. Based on our best knowledge, we classified the numerous image defogging approaches into two broad categories i.e. image enhancement and physical model restoration. Some classical and prominent defogging approaches were analyzed and elaborated in the term of basic principle, time consuming and typical application field. The validation of performance measurement also was discussed in detail. [20] A wavelet-based Retinex algorithm for unmanned aerial vehicle image defogging is proposed to avoid edge fuzziness, image dinginess, noise pollution and inefficiency, etc. in classical Retinex. In light of different energy distribution of fog, noise and edge information of subjects in the wavelet domain, this algorithm uses Retinex to restrain the influence of the fog, and adopts the wavelet threshold method to restrain noise while preserving the edge information, in order to reduce the influence of fog and noise of image. [21] To overcome the weakness of original dark channel prior algorithm on losing effectiveness in bright regions, an adaptive defogging algorithm was proposed. In this method, the fuzzy logic controller was adopted to automatically estimate the threshold of bright regions and the adjustment factor of transmission, and the misestimated transmission in bright regions was corrected using the adaptive threshold. [22] The fog images of Inland River often have low contrast. This paper introduces a optimized contrast enhancement algorithm. Firstly, divide the fog image by using the hierarchical searching method of quad-tree subdivision. Choose the brightest pixel as the atmospheric light in the final selected block. Then, combine the Mean Squared Error and the loss function. Next, get the optimal transmission value which can balance the contrast and the information loss. Then, fix the transmission with guide filter and adaptive window slide. Finally, restore the defogged image by solving the atmosphere attenuation model. [23] Image defogging has recently received attentions in many applications such as advanced drive assistance systems (ADAS) and intelligent surveillance systems to acquire high-quality images. This paper presents a novel depth-based image defogging method using stereo images. The depth information obtained from a pair of stereo foggy images and then fuzzy C-mean (FCM) clustering is applied to reduce matching errors caused by atmospheric

absorption and scattering during light propagation. The estimated depth information is used as weighting values in the dark channel prior (DCP)-in the defogging process. [24] Image defogging is a technique used extensively for enhancing visual quality of images in bad weather conditions. Even though defogging algorithms have been well studied, defogging performance is degraded by demosaicking artifacts and sensor noise amplification in distant scenes. It validate the theoretical analysis and observations for both synthesized datasets with ground truth fog-free images and natural scene datasets captured in a raw format. The rest of the paper is organised as follows. The second section provides the methodology on hybrid image defogging algorithm and the Depth fusion based defogging algorithm. The third section shows the result analysis and fourth section covering future scope with in conclusion.

2. PROPOSED METHODOLOGY

Image acquisition: Take the input image as we perform all possible operation on it. Figure 1 showing all the procedure related to haze removing algorithm.

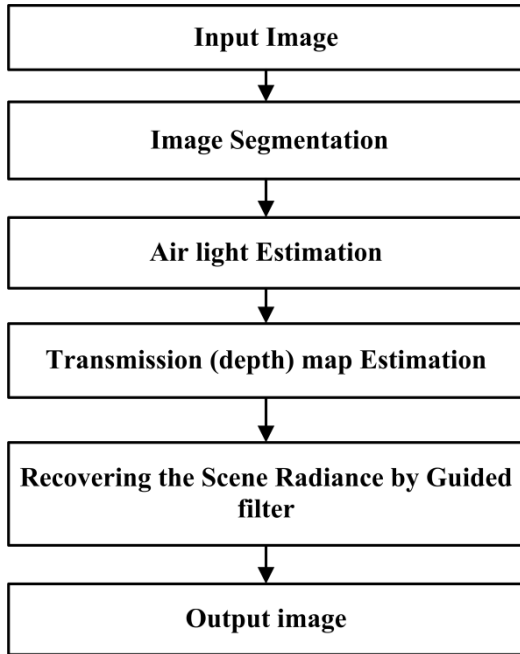


Fig 1: Flowchart of the proposed method

Here we describe the dehazing process in detail. The rough down-sampled transmission and the air-light are estimated firstly, and then the transmission is smoothed and up sampled using a guided filter, and finally the haze-free image is restored.

2.1 Extract the Transmission

The core of haze removal for an image is to estimate the airlight and transmission map. Assuming the airlight is already known, to recover the haze free image, the transmission map should be extracted first. He et al. [25] found that the minimum intensity in the non-sky patches on haze free outdoor images should have a very low value, which is called dark channel prior. Formally, for an image J, the dark channel value of a pixel x is defined as:

$$J^{dark}(x) = \min_{c \in \{r,g,b\}} (\min_{y \in \Omega(x)} (J^c(y))) \quad (1)$$

where, J^c is a color channel of J ; $\Omega(x)$ is a patch around x. By assuming the transmission in a local patch is constant and

taking the min operation to both the patch and three color channels, the haze imaging model in (1) can be transformed as:

$$\min_{c \in \{r,g,b\}} (\min_{y \in \Omega(x)} \left(\frac{I^c(y)}{A^c} \right)) = \tilde{t}(x) \min_{c \in \{r,g,b\}} (\min_{y \in \Omega(x)} \left(\frac{I^c(y)}{A^c} \right)) + (1 - \tilde{t}(x)) \quad (2)$$

where, $\tilde{t}(x)$ is the patch transmission. Since A is always positive and the dark channel value of a haze-free image J tends to be zero according to the dark channel prior, we have

$$\min_{c \in \{r,g,b\}} (\min_{y \in \Omega(x)} \left(\frac{I^c(y)}{A^c} \right)) \rightarrow 0 \quad (3)$$

Then the transmission can be exacted simply by:

$$\tilde{t}(x) = \min_{c \in \{r,g,b\}} (\min_{y \in \Omega(x)} \left(\frac{I^c(y)}{A^c} \right)) \quad (4)$$

Although the dark channel prior is not a good prior for the sky regions, fortunately, both sky regions and non-sky regions can be well handled by (4) since the sky is infinitely distant and its transmission is indeed close to zero. In practice, the atmosphere is not absolutely free of any particle even in clear weather. Therefore, a constant parameter ω ($0 < \omega \leq 1$) is introduced into (4) to keep a small amount of haze for the distant objects:

$$\tilde{t}(x) = 1 - \omega \min_{c \in \{r,g,b\}} (\min_{y \in \Omega(x)} \left(\frac{I^c(y)}{A^c} \right)) \quad (5)$$

The estimated transmission maps using (5) is reasonable. The main problems are some halos and block artifacts. This is because the transmission is not always constant in a patch. Several techniques were proposed to refine the transmission map, such as soft matting and guided joint bilateral filter. These techniques were applied on the transmission maps of the original foggy images and usually several operations should be used to achieve a good result, which could be computational intensive. For image haze removal, the time complexity is a critical problem that needs to be addressed. High time complexity of dehazing may make the algorithm impracticable.

2.2 Refine the Transmission

To improve the efficiency, in the present implementation, the transmission map is obtained from a down-sampled minimum channel image. Then, it is refined and up-sampled by using guided filter, which can be explicitly expressed by [28, 29]:

$$t_i = \sum_j W_{ij}(J^g) \tilde{t}_j \quad (6)$$

$$W_{ij}(J^g) = \frac{1}{|w|^2} \sum_{k:(i,j) \in w_k} \left(1 + \frac{(J_{i-\mu_k}^g)(J_{j-\mu_k}^g)}{\sigma_k^2 + \epsilon} \right) \quad (7)$$

Where, J_g is the guidance image; μ_k and σ_k^2 are the mean and variance of J_g in w_k ; $|w|$ is the number of pixels in w_k . ϵ is a regularization parameter. The refined operation on a down-sampled minimum channel image leads to a low time complexity and helps to reduce halos and block artifacts. Joint upsampling using guided filter is applied to obtain the full transmission map. The guided filter is reported to be a fast and non-approximate linear-time algorithm, which can perform as an edge preserving smoothing operator like the bilateral filter, but does not suffer from the gradient reversal artifacts. Moreover, the guided filter has an O(N) time (in the number of pixels N) exact algorithm for both gray-scale and color images.

2.3 Recovering the Scene Radiance

After the transmission map is estimated, the scene radiance can be recovered according to (1). The term $J(x) t(x)$ can be very close to zero. When the transmission $t(x)$ is close to zero, which make the recovered scene radiance J is prone to noise. Therefore, the transmission $t(x)$ is restricted by a low bound t_0 . The final scene radiance $J(x)$ is recovered by

$$J(x) = \frac{I(x)-A}{\max(t(x),t_0)} + A \quad (8)$$

Where, A is the airlight. There are many ways available in literatures to estimate the airlight [26, 27]. For simplicity, A takes the value of a pixel with highest dark channel value in this paper.

3. RESULTS AND DISCUSSION

The algorithm proposed here will remove haze from an image surface without prior knowledge of the haze location upon

that surface. The proposed method is based on determining the illumination profile of the image surface. This profile is then used to remove the haze.



Fig 2: Original Image of House and Park



Fig 3: (a) Defogged Image by using Multi scale Fusion (b) Defogged Image by using Universal Defogging (c) Defogged Image after Guided filter

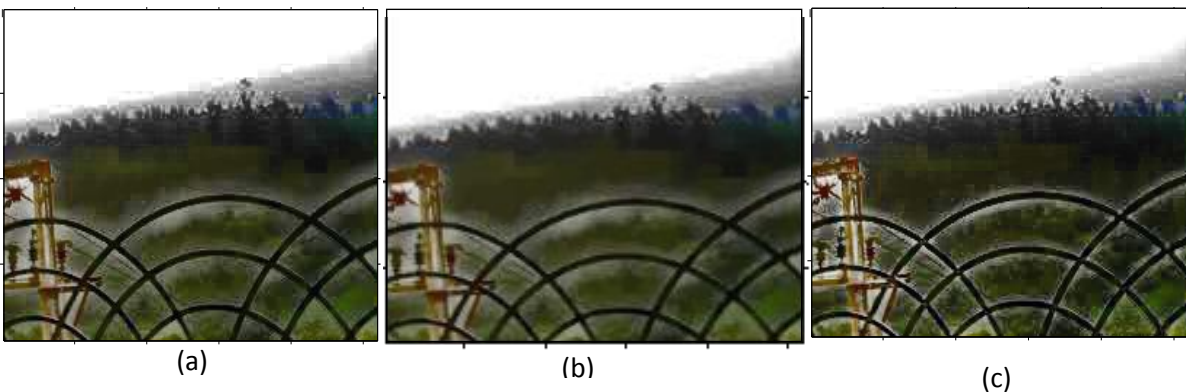


Fig 4: (a) Defogged Image by using Multi scale Fusion (b) Defogged Image by using Universal Defogging (c) Defogged Image after Guided filter.

Table 1. Comparison parameter for the house image

METHOD	VARIANCE	MEAN	SNR	UIQI
Multiscale fusion	0.1039	0.5315	6.2288	2.7719
Universal dehazing with guided filter	0.1344	0.4342	6.0875	2.5927

Table 2. Ccomparison parameter for the park image

METHOD	VARIANCE	MEAN	SNR	UIQI
Multiscale fusion	0.0337	0.3913	6.2345	4.8957
Universal dehazing with guided filter	0.0407	0.3463	8.0638	6.5275

It is implemented using MATLAB 7.9.0 (R2009b) on i-5 processor with 4-GB RAM. The simulations have been tested on aerial images in figure 3 and 4. Figure 2 shows the Original Image of House image of haze removed Image. The parameter comparison is shown in the table 1 and 2 for the multiscale and universal defogging method.

4. CONCLUSION AND FUTURE SCOPE

In this paper, a fast and effective method for real-time image and video defogging is proposed. Using a newly presented image prior - dark channel prior, haze removal for a single image without using any extra information is formulated as a particular filtering problem and an improved filtering scheme is proposed based on guided filter. In the presented algorithm, the air-light and the down-sampled transmission can be estimated and extracted easily. Then using a guided filter, the transmission can be further refined and up-sampled. Results demonstrate the presented method abilities to remove the fog layer and achieve real-time performance. It is believed that many applications, such as outdoor surveillance systems, intelligent vehicle systems, remote sensing systems, graphics editors, etc. could benefit from the proposed method.

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