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Hybrid Algorithm of Dark Chanel Prior and Guided filter for Single Image Dehazing

Nitit WangNo[1,*], Supailin Pichai[2]

[1]Major of Computer and Information Technology, Faculty of Information Technology, Roi Et Rajabhat University, Roi Et, 45120 Thailand

[2]Major of Computer Science, Department of Applied Science, Faculty of Science and Technology, Loei Rajabhat University, Loei, 42000 Thailand

[*]**Corresponding Author**: nitit@reru.ac.th

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Abstract

In this paper, we propose a hybrid algorithm of dark channel prior (DCP) and a guided filter for single image dehazing. First, it takes a haz image as the input, when cleaning the haze in the image with background area and low contrast. Next, in order to change the contrast and intensity of haze removal image with the proposed method. Then, a modified approach is applied to rebuilding the pixel of the resulting image. Reducing the sharpness and the air light expands the whiteness in the image capture. From the weather with fog and haze caused by floating particles, worsen the quality of the image. Haze removal algorithms are more useful for many applications in vision. The researcher has proposed a method to adjust the contrast and intensity of the image in removing the haze from The DCP method by using the guided filter. Which, the method we propose uses a variety of outdoor haze images test. Experimental results shown that the proposed approach outperforms, it was found that the DCP combining with guided filter algorithm haze methods give better performance in terms of mean structural similarity (MSSIM) and peak signal-to-noise ratio (PSNR), which is effective in hazing. Comparative results of the peak signal-to-noise ratio and image quality index demonstrate the robustness of the proposed methods model.

Keywords: Dark channel prior; haze removal; defog; Guided filter

1. Introduction

In the hazy weather, the images taken with an optical device tend to be blurred as the breakage and absorption of atmospheric particles may result in a lack of clarity and visibility. And it brings difficulties to the application of vision and data analysis [1]. Therefore, removing the haze from the image effectively is a challenging and worthy problem.

In recent years, many researchers have conducted in-depth research about techniques and methods for solving problems related to removing haze images. Which, eliminates a single haze image and another way is to restore clear images using multiple images or additional information [2], which these algorithm have accurate results, but there are higher limitations for obtaining image processing. Therefore, eliminating double images in a single image is a popular spot for research on dehazing techniques. This method produces satisfactory results, but easy to bring distortion of color and radius [3 – 5]. At about the same time Fatal [6] in the albedo assessment section of the scene by Independent Component Analysis (ICA) like assuming that signal and surface function have no relation to local, and the realizes the image dehazing. This method has quality results, but is unable to handle images that do not fit the assumption.

The focus of this paper is therefore to improve the effectiveness of the dark channel prior combine guided filter methodology on statistics lots of outdoor clear images, thereby eliminating natural images. Which has research studies the type of DCP [7 – 9], and we propose a hybrid DCP with guided filter. Section II outlines the justification for our research and provides background information that supports our work and our proposed methodology. In Section III, we present the qualitative and quantitative results of the proposed method [supported by the peak signal-to-noise ratio (PSNR) and mean structural similarity (MSSIM)]. Our conclusions are presented in the final section.

2. Materials and methods

In this section materials and method the approach of single image hazes removal using dark channel prior and the guided filter.

Haze Image Model

When referring to the image that were taken with haze proposed by McCarteny [10] is widely used, can be described by the computer as follows:

$$I(x) = t(x)J + (1 - t(x))A \tag{1}$$

where I is the intensity of the haze image, x is the pixel, J is the clarity of the image that is haze, t is moderate signal transmission show light fragments that are not scattered, and A is the overall atmospheric light.

Dark Channel Prior

For the Dark channel prior to the hypothesis of the estimation of light in the atmosphere by dehazed the image to get the real results, it is mainly used by patches; not-sky. This is the one color channel has a low intensity, not just a few pixels as in the equation below [11].

$$J^{dark}(x) = \min_{c \in \{r,g,b\}} \left(\min_{y \in \Omega(x)} (J^c(y)) \right) \tag{2}$$

where J^{dark} is the dark channel of J, J^c is color of J and $\Omega(x)$ is a local patch centered at x, and the statistical observation is name as dark channel prior.

Guided Filter

The Guided filter is a technique that is more effective than bilateral filter to preserve edges while removing small fluctuations in the transmission map. By defining filters for linear variances which the process involves guidance in the image I, which filters image input p, and image output q. The filtering output at pixel i is expressed as a weighted average [12]:

$$q_i = \sum_j W_{ij}(I) p_j , \tag{3}$$

where i and j are the pixel indexes. The W_{ij} kernel is a function of the image path I and independent of p. This filter is linear compared to p.

In general, the concrete of these filters is bilateral filter. This kernel W^{bf} is given by.

$$W_{ij}^{bf}(I) = \frac{1}{K_i} \exp\left(-\frac{|x_i - x_j|^2}{\sigma_s^2}\right) \exp\left(-\frac{|I_i - I_j|^2}{\sigma_r^2}\right) \tag{4}$$

where x is the coordinate of the pixel, and K_i is a normalizing parameter to ensure that $\sum_j W_{ij}^{bf}$=1. The parameter σ_s and σ_r adjust the spatial similarity and the rage (intensity/color) similarity. The joint bilateral filter reduced to the traditional bilateral filter when I and p are the same.

Definition

From the above method, the filter and its kernel have been defined. An important assumption of the filter is a local linear model between the I instruction and the output filter q we suppose q is the linear transformation of I in the window ω_k, centered at pixel k:

$$q_i = a_k I_i + b_k, \forall i \in \omega_k, \tag{5}$$

where (a_k ,b_k) are some expected linear coefficients in ω_k. We use the square window of a radius r. This local linear model makes sure that q has an edge only when I have an edge, because $\nabla q = a\nabla I$.

When looking for linear coefficient in reducing the differences between q and the filter input p. especially, when will reduce the following cost function in the window:

$$E(a_k, b_k) = \sum_{i \in \omega_k} ((a_k I_i + b_k - p_i)^2 + \in a_k^2) \tag{6}$$

Here ϵ is a prevention of standardization parameters a_k from being too large. The solution to (6) can be given by linear regression:

$$a_k = \frac{\frac{1}{|\omega|}\sum_{i\in\omega_k} I_i p_i - \mu_k \bar{p}_k}{\sigma_k^2 + \in} \tag{7}$$

$$b_k = \bar{p}_k - a_k \mu_k \tag{8}$$

Here, σ_k^2 and μ_k are the variance and mean of I in ω_k, $|\omega|$ is the number of pixels in ω_k, and $\bar{p}_k = \frac{1}{|\omega|}\sum_{i\in\omega_k} p_i$ is the mean of p in ω_k.

Proposed method

We improvement of the proposed dehazing technique is show (Fig. 1). From the characteristics of the image that is affected between the foreground and background distribution mentioned the shortcomings of DCP method we have analyzed, we present an algorithm to improve the image dehazing by creating the pixel of image after the DCP method and combine guided filter. We then made a pixel specification with a newly created pixel better dehazing result.

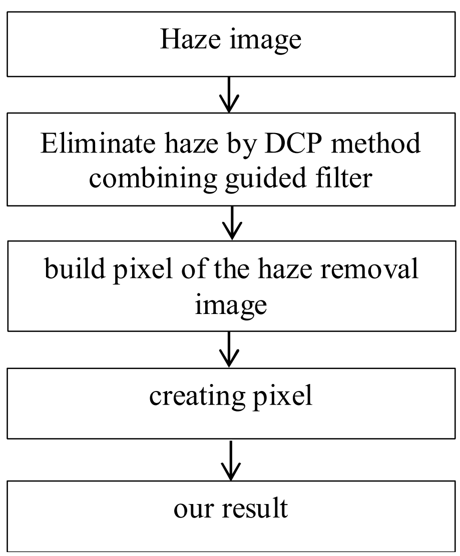


Fig.1 The flow chart proposed method.

The steps of improved method are as follows:

Create a haze image of A and find the x_A (Equation 1) intensity that corresponding to the highest point in the high- intensity region of the pixel.

Eliminate the haze in the image by using the DCP method that combines the guided filter and then creates the pixel p of the image, removing the haze and then find the x_p origin of the sharp point in pixel p.

Create p. We use the enhancement of p' instead of p (Equation 3) to enhance the sharpness and rid the sharp points. In this paper, we use the quadratic function to replace p. We set x_p and x_A to the beginning and end respectively.

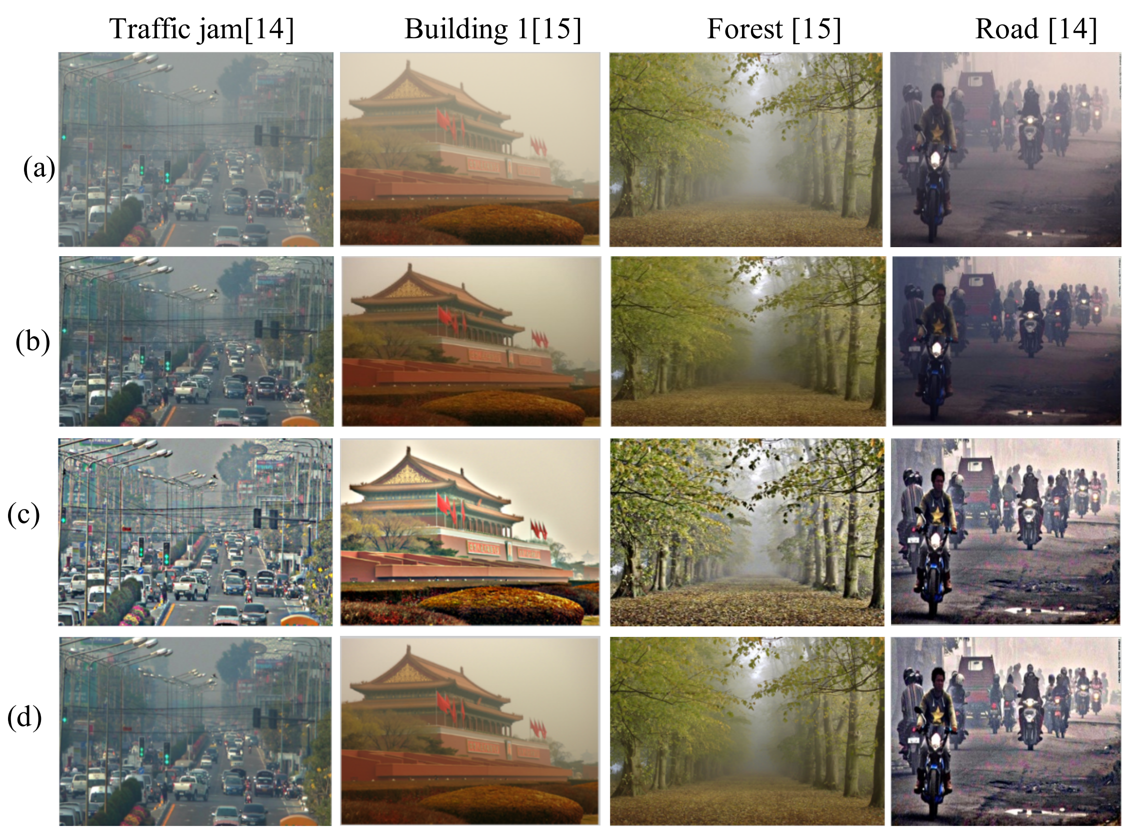
Finally, make a pixel specification by creating a new B' pixel. Then we get the result image.

3. Result and discussion

In the experiment, we shall discuss the performance results of the proposed approach, then compare our method with the state-of-the-art methods, including DCP, guided filter and proposed. All the methods are implemented in the MATLAB 2015a environment on an i5-3.30 GHz PC with 16GB RAM, by using 15 images [13] in the experiment which have different sizes. The comparison datasets include indoor and outdoor real-word images. Which, the researcher calculated the mean squares error (MSE) to analyze the significance of different feature. A low MSE indicates satisfactory that the dehazing result, while a high MSE means poor ability to eliminate dehazing capability (Fig. 3). We could also assess the experiment results in objective evaluation criteria, mean structural similarity index (MSSIM) and peak signal-to-noise ratio (PSNR) were shown in Table 1.

A. Qualitative comparison

The haze elimination algorithm that we offer can work well for a variety of haze images. In our experiments, as whole experimental methods able to get good results by dehazing general outdoor images. Fig 2 show the dehazing images and the depth maps. In Fig 2, our result is comparable to the proposed method, and show that our approach outperforms. Which the experiment is equivalent to dark-object subtraction method applied for each color channel of the images.



Community [14] Outdoor1 [14] Bridge [14] Outdoor2 [14]

(a)
(b)
(c)
(d)

Train [15] House [15] People1 [15] People2 [15]

(a)
(b)
(c)
(d)

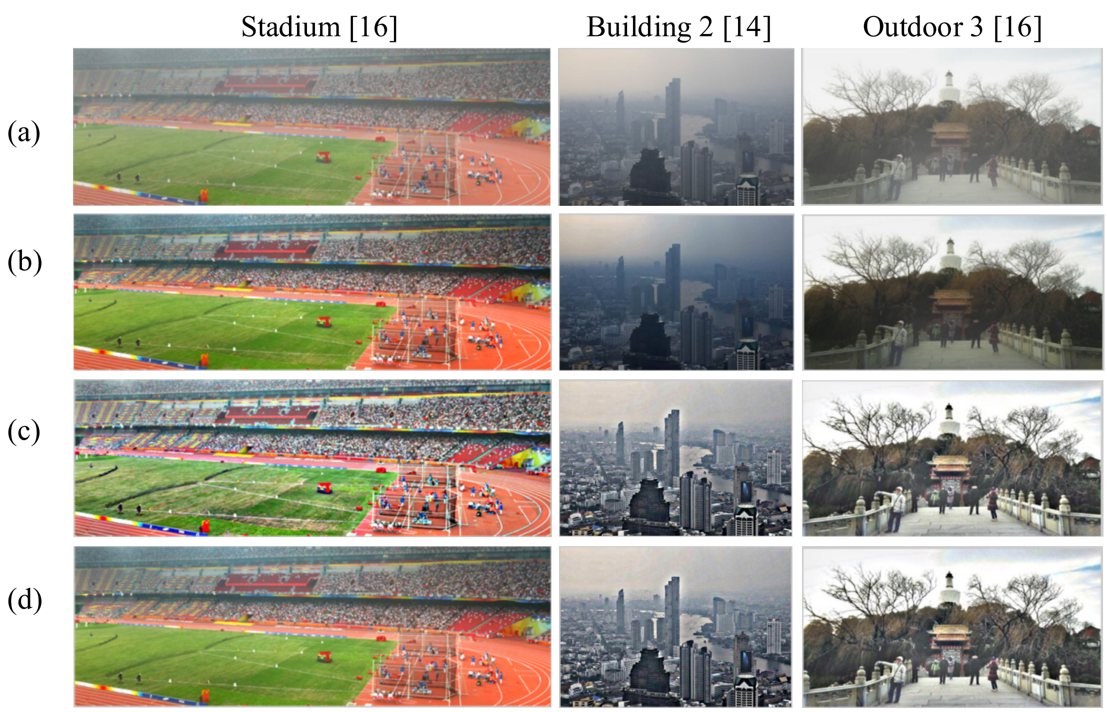


Fig. 2 Qualitative result on real-world image; (a) the hazy image; (b) DCP method; (c) guided filter method; d proposed method.

Experiment: Quantitative evaluation

In the first results, the performance of the proposed method is compared with state of the art (DCP) algorithms from a total of 15 images with the elimination of air-light transmitted in the atmosphere. PSNR and MSSIM values for the highest noise intensity are shown in the Table 1, in which the best values are highlighted.

Table 1 The comparison of parameter values dehazing to the test image.

Image	DCP		Guided filter		Proposed	
	PSNR (dB)	MSSIM	PSNR (dB)	MSSIM	PSNR(dB)	MSSIM
Traffic Jam	64.60	0.76	65.55	0.54	**66.97**	**0.83**
Building1	64.52	0.79	**67.04**	0.69	66.63	**0.87**
Forest	67.06	0.87	63.91	0.60	**68.76**	**0.92**
Community	61.30	0.76	**75.81**	0.75	63.75	**0.83**
Outdoor 1	63.09	0.77	**70.79**	0.74	65.22	**0.86**
Train	62.85	0.78	65.04	0.64	**65.11**	**0.86**
Stadium	66.61	0.81	63.76	0.62	**68.72**	**0.87**
Bridge	63.98	0.87	63.99	0.69	**65.75**	**0.92**
House	66.54	0.82	63.88	0.69	**72.54**	**0.92**
People 1	68.30	0.90	63.85	0.77	**69.51**	**0.96**
Building 2	64.96	0.79	67.82	0.84	**67.85**	**0.89**
Road	64.82	0.76	66.10	0.82	**66.14**	**0.84**
People 2	67.13	0.80	69.80	0.81	**69.85**	**0.82**
Outdoor 2	61.97	0.63	67.09	0.62	**67.12**	**0.64**
Outdoor 3	64.80	0.81	66.13	0.80	**66.16**	**0.83**

Table 1 outlines the results of the dehazing methods after removing in terms of both PSNR and MSSIM values. It can be seen that the performance of the proposed dehazing vile layer algorithm. Visual comparison confirms that all of the comparative dehazing combining DCP with the guided filter algorithms.

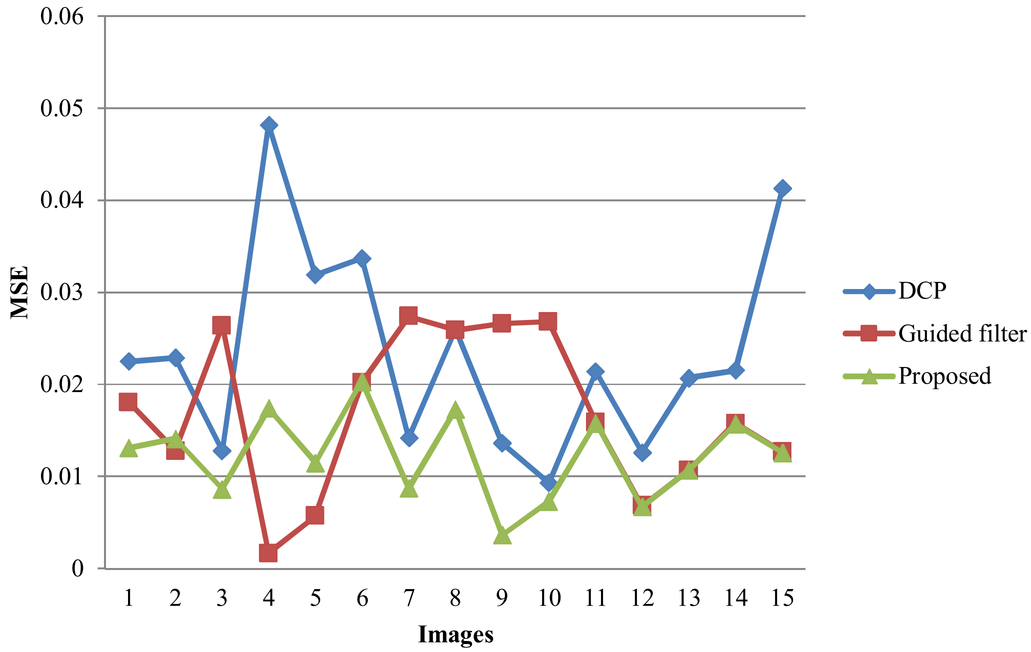


Fig. 3 Quantitative comparisons dataset by MSE value.

4. Conclusion

Hazing image clarity is an important problem in computer vision. This paper presents an algorithm that produces image clarity after DCP and creates a guided filter to improve air-light and contrast images, which results from the DCP process; the images will have light and contrast distortion. By considering the analysis of haze like covering or take as fogs while the transmission. Our algorithm results in visually satisfying results and tends to maintain the main details better than other techniques. Compared to our proposed algorithm, there are two main advantages: 1) the structure (MSSIM) of the image is effective compared to other methods, and 2) The PSNR values outperform while maintaining comparable performance. Based on comparative studies and quantitative assessments, demonstrating the effectiveness of our methods can be improved by using a higher haze model. A researcher has shown that the proposed method can create real-time and good haze, the covered layer that will be removed or the transmission that is separated from the original fog images. However, the guided filter has taken that proposed with DCP to customize the atmospheric light transmission to increase the efficiency of eliminating haze image. The studies will find that guided filter will haze distortion well (0.30% as PSNR higher), but the structure of the image is also lower (MSSIM). Therefore, to increase the efficiency of eliminating the single image haze compared to other algorithm. The experiments that we present show that the effective removal of haze and the structure of high- performance images.

5. References

[1] H. Li-hong, Defogging method for degrade image, Infrared Laser Eng., (2010) 985 – 988.

[2] L. Schaul, C. Fredembach, S. Susstrunk, Color image dehazing using the near-infrared, Internationnal Conference on Image Processing 2009, Cairo in Egypt. 7 – 10 November 2009, 1606 – 1612.

[3] P. Chavezr, An improved Dark-Object Subtraction Technique for Atmospheric Scattering Correction of Multispectral Data, Remote Sens. Environ., 24 (1998) 450 – 479.

[4] R. Tan, Single image dehazing, ACM Siggraph, 27(2008) 1 – 9.

[5] Z. Li, P. Tan, R.T. Tan, D. Zou, S.Z. Zhou, L.F. Cheong, Simultaneous video defogging and stereo reconstruction, IEEE Conference on Computer Vision and Pattern Recongnition (CVPR) 2015, Boston, MA, USA. 7 – 12 June 2015, 4988 – 4997.

[6] R. Fattal, Visibility in bad weather from a single image, IEEE Conference on Computer Vision and Pattern Recognition 2008, Anchorage in AK, USA. 05 August 2008, 1 – 8.

[7] B. Li, W. Ren, RESIDE: A benchmark for single image dehazing, J. Class files.14 (2017) 492 – 505.

[8] F. Shai, W. Feng, Z. Ji-Qing, Simultaneous Dehazing and Denoising of single hazing image , FR&AI, 5 (2012) 136 – 142,

[9] J. Jian-guo, H. Tian-feng, Q. Mei-bin, Improved algorithm on image haze removal using dark channel prior, JOCS, 16 (2011) 7 – 12.

[10] R. Fattal, Visibility in bad weather from a single image, IEEE Conference on Computer Vision and Pattern Recognition 2008, Anchorage in AK, USA. 05 August 2008, 1 – 8.

[11] S. Chang Pei, L. Tzu-Yen, Effective Image Haze Removal Using Dark Channel Prior And Post-processing, IEEE International Symposium on Circuits and Systems (ISCAS), Seoul, South Korea. 20 August 2012, 2777 – 2780.

[12] K. He, J. Sun, X. Tang, Guided Image Filtering, in: Daniilidis K., Maragos P., Paragios N. (Eds.), Computer Vision – ECCV 2010, Springer, Heidelberg, 2010, pp. 1 – 14.

[13] Single Image Dehazing, http://johanneskopf.de/publications/deep_photo/index.html, 30 October 2019.

[14] Thailand haze image, https://en.vietnamplus.vn/thailand-laos-ink-pollution-management-deal/117775.vnp, 31 October 2019.

[15] Single Image Dehazing, https://www.cse.huji.ac.il/~raananf/projects/defog/index.html, 30 October 2019.

[16] Input haze image, http://kaiminghe.com/cvpr09/comparisons.html, 29 October 2019.