ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 3, March 2017

A Survey on Visibility Restoration Techniques for Single Hazy Images

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ABSTRACT: Haze formation is the combination of air light and attenuation. Attenuation decreases the contrast and air light increases the whiteness in the scene. Atmospheric conditions created by floating particles such as fog and haze, severally degrade image quality. Removing haze from single image of a weather degraded scene found to be a difficult task because the haze is dependent on the unknown depth information, haze removal algorithms become more beneficial for many vision applications such as surveillance system, object detection, tracking and segmentation. In this paper, we represent general survey on the research in the field of image processing on haze removal. Finally, paper is concluded towards challenges in haze removal using single image for future research.

KEYWORDS*:* Haze, Dark Channel Prior, Dehazing, Atmospheric Light.,

I. INTRODUCTION

Different weather conditions such as haze, fog, smoke, rain, or snow will cause complex visual effects of spatial or temporal domains in images. Such effects may significantly reduce the performances of outdoor vision systems trusting on image feature extraction or visual attention modeling, such as event detection, object detection, tracking, and recognition, scene analysis and classification, image indexing and retrieval. Removal of weather effects has recently received much attention, such as removals of haze, rain, and snow from image. In this paper, we focus on haze removal, i.e., dehazing, from single image. Based on the fact that the amount of scattering depends on the distance of the scene points from the camera, the degradation is spatially variant also haze is dependent on the unknown depth, dehazing is therefore a challenging problem. If the available input is only one single hazy image, the problem is under-constrained. Hence, all of the customary dehazing approaches have been proposed by using multiple images or additional information. Polarization-based methods were proposed to remove the haze effects through two or more images taken with different degrees of polarization.

More limitations obtained from multiple images of the same scene under different weather conditions were employed for haze/weather effect removal. Moreover, in depth-based methods, it is required to provide some depth information from user inputs or known 3D models for dehazing or de-weathering. However, taking multiple input images of the same scene is usually unfeasible in several real applications. Single image haze removal has recently received much attention. The success of these methodologies usually lies on using stronger priors or assumptions. It is observed that a haze-free image should have higher contrast compared with its hazy version. Hence, it was proposed to remove haze from a single image by maximizing the local contrast of the restored image. The results are usually visually fascinating but may not be physically valid. Scattering is caused by two fundamental phenomena such as attenuation and airlight.

Haze attenuates the light reflected from the scenes, and further blends it with some additive light in the atmosphere. The target of haze removal is to improve the reflected light (i.e., the scene colors) from the mixed light. The constancy and strength of the visual system can improve by the usage of effective haze removal of image. There are many methods available to remove haze from image like polarization, independent component analysis, dark channel prior etc.

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II. DEHAZING METHODS

Haze Removal methods can be grouped into two categories that are multiple image haze removal and single image haze removal.

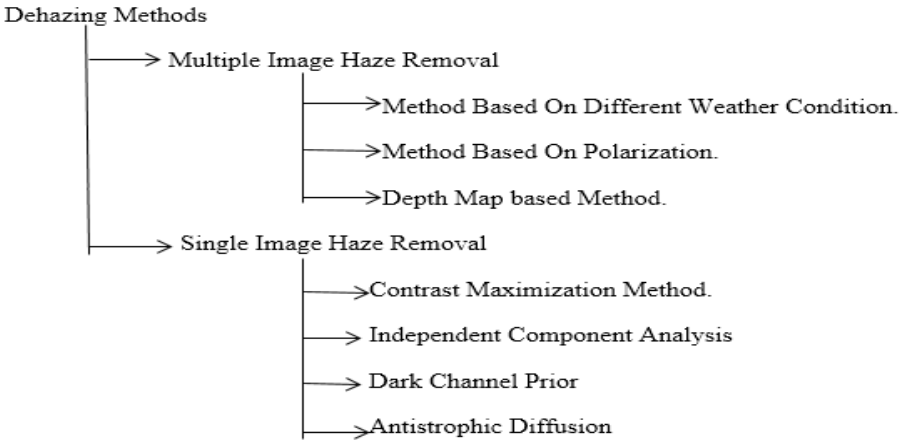

Figure.1 Classification of Dehazing Methods.

A. MULTIPLE IMAGES DEHAZING METHOD

In this haze removal, two or more images or multiple images [12], [14], [15], [23] of the same scene are taken. This method achieves known variables and avoids the unknowns. The methods come under this category are explained as follows.

B. METHOD BASED ON DIFFERENT WEATHER CONDITION

This method is to use more than one image [12], [13], [15] taken from different weather condition. The basic method is to take the differences of two or more images of the analogous scene. These multiple images have different properties of the subsidizing medium. This tactic can significantly improve visibility, but its hindrance is to wait until the possessions of the medium change. So, this method is unable to convey the results instantly for scenes that have never been encountered before. Additionally, this method also cannot handle active scenes.

C. METHODS BASED ON POLARIZATION

In this method two or more images of the same sight are taken with different polarization filters [14], [17]. The basic method is to take many images of the same scene that have different gradations of polarization, which are assimilated by rotating a polarizing filter attached to the camera, but the conduct effect of active scene is not very good. The inadequacy of this method is that it cannot be applied to lively scenes for which the changes are speedier than the filter rotation and require special apparatus like polarizers and not necessarily produce better results.

D. DEPTH MAP BASED METHOD

This method uses depth information for haze removal. This method uses a single image and assumes that 3D geometrical model [15], [16], [19] of the scene is provided by some databases such as from Google Maps and also assumes the consistency of the scene is given from satellite or aerial photos. This 3D model then lines up with hazy image and provide the sight depth [18]. This method requires user collaboration to align 3D model [19] with the scene and it gives precise results. This method does not require special apparatus. Its limitation is that it is not involuntary, it needs user interactions. This method is to use some degree of interactive guidance to dehaze the image, but it needs calculation of more parameters, and the supplementary information difficult to obtain.

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E. SINGLE IMAGE DEHAZING METHOD

This method only requires a single input image [1, 20]. This method relies upon numerical assumptions [5] and or the nature of the scene and improves the scene evidence based on the prior information from a single image. This method becomes more and more researcher'sattentiveness. The methods come under this category are described as follows.

F. CONTRAST MAXIMIZATION METHOD

Haze reduces the contrast. Eliminating the haze enrich the contrast of the image. Contrast maximization [1] is a method that improves the contrast under the constraint. But, the subsequent images have larger capacity values because this method does not actually improve the brightness or depth but somewhat just enhance the visibility. Moreover, the result contains halo effects at depth cutoffs.

G. INDEPENDENT COMPONENT ANALYSIS (ICA*)*

ICA is a statistical method to separate two improver components from a signal. Fattal [20] uses this method and adopts that the transmission and surface covering are statistically uncorrelated in local area. This approach is physically valid and can produce good results, but may be defective because it does not work well for thick haze.

H. DARK CHANNEL PRIOR

The dark channel prior [5] is based on the information of outdoor haze-free images. In most of the non-sky patches, at least one color channel (RGB) has very low intensity at some pixels (called dark pixels). These dark pixels provide the assessment of haze transmission. This methodology is substantially valid and work well in solid haze. When the scene entities are similar to the air light then it is unacceptable.

I. ANTISTROPHIC DIFFUSION

Anisotropic diffusion [11] is a technique that decreases haze without eliminating image parts such as edges, lines or other details that are vital for the understanding of the image. Its flexibility permits to syndicate smoothing properties with image enrichment qualities. [12] present an algorithm uses anisotropic diffusion for refining air light map from dark channel prior. Antistrophic diffusion is used to suave the airlight map. It performs well in case of dense fog.

III. VISIBILITY RESTORATION TECHNIQUE

For removing haze, fog from the image various techniques are used, but most used techniqueof dehazing images preferred by most researchers is Dark Channel Prior:
Dark channel prior [12] is used for the valuation of atmospheric light in the haze free image to get the more genuine result. This method is mostly used for non-sky patches which assumes that at least in one color channel image have very low intensity at few pixels. The low intensity in the dark channel is mainly because of three components:

- Colorful objects or surfaces
- Shadows
- Dark objects or surfaces

As the outdoor images are usually full of shades the dark channels of images will be really dark. Due to fog (airlight), a hazy image is brighter than dehazed image . So it can be assumed that dark channel of foggy image will have higher intensity in region with higher fog. hence, visually the intensity of dark channel is a coarse valuation of the thickness of fog. In dark channel prior there are pre and post processing steps for getting good results. In post processing steps use is soft matting or trilateral filtering etc.

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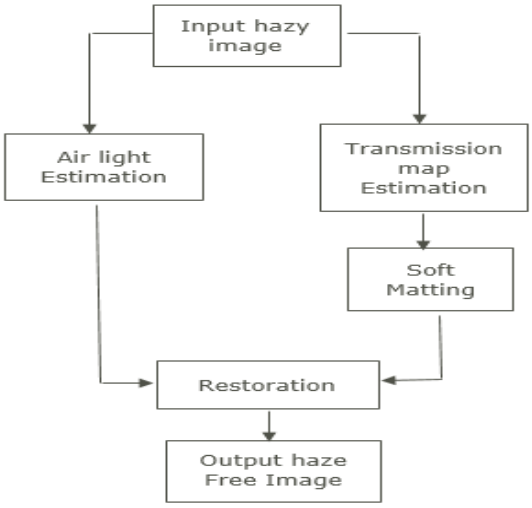

FigureII. Block Diagram Of Dark Channel Prior Technique.

As the dark channel prior is a generous of statistic, it maynot take effort for some specific images. When the scene objects are characteristically similar to the atmospheric light and no shadow is cast on them, the dark channel prior is invalid.

SR. NO	METHOD NAME	INPUT IMAGE	OUTPUT IMAGE	COMMENT
1	Method Based On Different Weather Condition			This method failed because of unavailability of reference images and also not efficient on dynamic scene.
2	Method Based On Polarization.			This method required expensive equipment also failed in case of dynamic scenes.
3	Depth Map Based Method			This is not an automated method needs user's interaction to adjust input parameters which will be time consuming.

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4	Contrast Maximizatio n Method			This method only improves the visibility But it doesn't improve the vividness and contains halo effects.
5	Independent Component Analysis			This method gives valid results but may be failed in case of dense haze.
6	Dark Channel Prior			This method gives excellent results but somewhere failed in case bright pixels like sky region.
7	Antistrophic Diffusio			It performs very well in case of heavy haze also.

Table 1: Summary ofDehazing Methods

IV. EXISTING LITERATURE

Kaiming He, Xiaoou tang proposed a dark channel prior model to remove haze from single image. But its results have some drawbacks such that when atmospheric light and scene object are similar and shadow is cast on them the model is invalid and generate artifacts. Even in some cases this model does not generate efficient transmission map [35]. Soo-Chang Pei, Tzu-Yen Lee proposed a new method where it can be applied to various dense and distribution haze images without sacrificing color naturalness by using refined Dark Channel Prior(DCP) and adding post processing. Experimental results demonstrate that the new method provides higher dehazing quality and can be integrate to another dehazing method to reduce complexity and improve image quality [34].

Soo-Chang Pei, Tzu-Yen Lee invent a method using dark channel prior and bilateral filter in local contrast correction and got results having reliable capabilities for removing nighttime haze. The proposed method is robust and maintains quality over a limitation case at night time. Future scope of this method is to integrate with another dehazing method to adapt for every different input image [33].

Wei-Jheng Wang and Bo-Hao Chen estimate the method using depth estimation and visibility restoration by taking advantage of refined transmission based on gray world assumption. This model is useful for edge preservation and effectively remove halo effects and artifacts [30].

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Ramandeep Kaur, Nitika Kapoor have done survey on various fog removing methods and they conclude that, the results of different algorithms vary as per the input density of foggy image. Also the image quality reduces with increase in light to image. According to them traditional filters are not efficient for image enhancement so we can use soft computing in future [36]. Andrey Kopylov, Oleg Seredin, propose a novel haze removal approach based on the proposed hybrid dark channel prior technique in order to remedy the problems associated with localized light sources during image restoration [32].

Hyungjo Park, Dubok Park, use local atmospheric light and estimate the media trans- mission for each local region by using an objective function represented by modified saturation evaluation metric and intensity difference and achieved restoration in terms of contrast. In future investigation of the dehaze algorithms for haze images under low light condition will be carry on [31]. Yadwinder Singh, Er. Rajan Goyal estimate a new haze removal technique HDCP which will integrate dark channel prior with CLAHE to remove the haze from color images and bilateral filter is used to reduce noise from images [37].

Won-Tae Kim, Hyun-Woo Bae used method of maximum filter to avoid artifacts formation during transmission estimation without violating the quality of image. It reduces the execution time of algorithm as compare to other conventional method [25].

Zhengguo Li, Jinghong Zheng, used simplified dark channel for map estimation and further refined it using content adaptive guided image filter to recover image. Proposed algorithm outperforms existing algorithms. The proposed algorithm works in either the speed point of visor quality point of view. This algorithm has its limitation as like He's model [29].

Zhengguo Li and Jinghong Zheng used weighted guided image filter to decompose simplified dark channel of the haze image into a base and a detail layer. The transmission map is estimated from the base layer, and it is applied to restore the haze-free image. They introduce an interactive mode to the proposed algorithm which allows a user to removal haze according to her/his preference, but the estimation level of haze is not accurate [28].

Yuxiang Shen, Xiaolin Wu, Xiaowei Deng analyzed the effects of invalid dark channel assumption on dehazed images; in particular, it reveals the causes and behavior of spectral distortions that are inherent to the dark channel type of dehazing methods. Thus they found the drawbacks of dark channel prior. [27]

Yu Li, Robby T. Tan, Michael S. Brown introduced framework that reduces effect of glow in images and recover hazy images captured at nighttime. But the problem with their approach was they were not able to estimate the varying atmospheric light so it introduced noise and artifacts which affect the image quality [26].

VeeranjaneyuluToka,NandanHosagraharaSankaramurthy estimate the method that uses single frame for enhancing foggy images using multilevel transmission map. The method is fast and free from noise and artifacts. They also tried the application on Samsung galaxy S6. Future work based on fog removal from HD images [24].

V. CONCLUSION

In this survey we studied that most of the method above used Dark prior channel as a base to their estimation. As we have seen the dark channel prior has some drawbacks, hence these methods results are not efficient in some cases. There are some methods which gives high quality images but these are not applicable to varying weather conditions. So first there is needed to overcome drawback of dark channel prior and estimate good result.

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ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

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Vol. 5, Issue 3, March 2017

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