A Review on Different Image Dehazing Methods

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ABSTRACT:

This paper presents a review on the different haze removal techniques. Haze brings trouble to many computer vision/graphics applications as it diminishes the visibility of the scene. Haze is formed due to the two fundamental phenomena that are attenuation and the air light. Attenuation reduces the contrast and air light increases the whiteness in the scene. Haze removal techniques recover the color and contrast of the scene. These techniques are widely used in many applications such as outdoor surveillance, object detection, consumer electronics etc. The overall objective of this paper is to explore the various methods for efficiently removing the haze from digital images. This paper ends up with the short comings of the existing methods.

Keywords: Airlight, Attenuation, Image Dehazing, Contrast enhancement, Polarizers, ICA, Depth, DCP.

[1] INTRODUCTION

Bad weather condition such as haze [22], mist, fog and smoke degrade the quality of the outdoor scene. It is an annoying problem to photographers as it changes the colors and reduces the contrast of daily photos, it diminishes the visibility of the scenes and it is a threat to the reliability of many applications like outdoor surveillance, object detection, it also decreases the clarity of the satellite images and underwater images. So removing haze from images is an imperative and broadly demanded area in computer vision and computer graphics.

The image quality of outdoor scene in the haze, fog, mist and other bad weather condition is usually degraded by the scattering of a light [13,22] before reaching the camera due to these large quantities of suspended particles (e.g. fog, haze, smoke, impurities) in the atmosphere. This phenomenon affects the normal work of automatic monitoring system, outdoor recognition system, tracking & segmentation and intelligent transportation system. Scattering is caused by two
fundamental phenomena such as attenuation [13, 22] and airlight [13, 22]. 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.

[2] DEHAZING METHODS

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

[2.1] MULTIPLE IMAGE 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 attains known variables and avoids the unknowns. The methods comes under this category are explained as follows.

[2.1.1] METHOD BASED ON DIFFERENT WEATHER CONDITION

This method is to use multiple images [12, 13, 15] taken from different weather condition. The basic method is to take the differences of two or more images of the similar scene. These multiple images have different properties of the contributing medium. This approach can significantly improve visibility, but its disadvantage is to wait until the properties of the medium change. So, this method is unable to deliver the results instantly for scenes that have never been met before. Moreover, this method also cannot handle dynamic scenes.

Figure 1. Multiple Image dehazing [22]
[2.1.2] METHODS BASED ON POLARIZATION

In this method two or more images of the same scene are taken with different polarization filters [14, 17]. The basic method is to take multiple images of the same scene that have different degrees of polarization, which are acquired by rotating a polarizing filter attached to the camera, but the treatment effect of dynamic scene is not very good. The shortcoming of this method is that it cannot be applied to dynamic scenes for which the changes are more rapid than the filter rotation and require special equipment like polarizers and not necessarily produce better results.

![Image dehazing using polarizing filters](image)

(a) Best Polarization State  (b) Worst Polarization State  (c) Dehazed Image

Figure: 2. Image dehazing using polarizing filters [14]

[2.1.3] 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 texture of the scene is given (from satellite or aerial photos). This 3D model then aligns with hazy image and provides the scene depth [18]. This method requires user interaction to align 3D model [19] with the scene and it gives accurate results. This method does not require special equipment’s. Its shortcoming is that it is not automatic, it needs user interactions. This method is to use the some degree of interactive manipulation to dehaze the image, but it needs an estimation of more parameters, and the additional information difficult to obtain.
[2.2] SINGLE IMAGE DEHAZING METHOD

This method only requires a single input image [1, 20]. This method relies upon statistical assumptions [5] and the nature of the scene and recovers the scene information based on the prior information from a single image. This method becomes more and more researcher’s interest. The methods come under this category are explained as follows.

[2.2.1] CONTRAST MAXIMIZATION METHOD

Haze diminishes the contrast. Removing the haze enhance the contrast of the image. Contrast maximization [1] is a method that enhances the contrast under the constraint. But, the resultant images have larger saturation values because this method does not physically improve the brightness or depth but somewhat just enhance the visibility. Moreover, the result contains halo effects at depth discontinuities.

[2.2.2] INDEPENDENT COMPONENT ANALYSIS (ICA)

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

![Hazy Image](image1) ![Haze-free image](image2)

Figure: 5. Independent component analysis [21]

### [2.2.3] DARK CHANNEL PRIOR

The dark channel prior [5] is based on the statistics 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 estimation of haze transmission. This approach is physically valid and work well in dense haze. When the scene objects are similar to the air light then it is invalid.

![Hazy Image](image3) ![Recovered Depth map](image4) ![Haze-free image](image5)

Figure: 6. Dark channel prior [5]

### [2.2.4] ANTISTROPHIC DIFFUSION

Anisotropic diffusion [11] is a technique that reduces haze without removing image parts such as edges, lines or other details that are essential for the understanding of the image. Its flexibility permits to combine smoothing properties with image enhancement qualities. Tripathi

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[12] present an algorithm uses anisotropic diffusion for refining air light map from dark channel prior. Antistrophic diffusion is used to smooth the airlight map. It performs well in case of heavy fog.

![Image of hazy and haze-free image](image)

(a) Hazy image  
(b) Haze-free image  

Figure: 7. Antistrophic diffusion [11]

[3] LITERATURE SURVEY

Robby T. Tan (2008) [1] has introduced an automated method that only requires a single input image. Two observations are made based on this method, first, clear day images have more contrast than images afflicted by bad weather; and second, airlight whose variant mostly depends on the distance of objects to the observer tends to be smooth. Tan [1] develops a cost function in the framework of Markov random fields based on these two observations. The results have larger saturation values and may contain halos at depth discontinuities.

Tarel et al. (2009) [2] have demonstrated algorithm for visibility restoration from a single image that is based on a filtering approach. The algorithm is based on linear operations and needs various parameters for adjustment. It is advantageous in terms of its speed. This speed allows visibility restoration to be applied for real-time applications of dehazing. They also proposed a new filter which preserves edges and corner as an alternate to the median filter. The restored image may be not good because there are discontinuities in the scene depth.

Yu et al. (2010) [3] have proposed a new fast dehazing method based on the atmospheric scattering model. The atmospheric scattering model is simplified earlier to visibility restoration. First they acquire a coarse approximation of the atmospheric veil and then the coarser estimation is smoothed using a fast bilateral filtering approach that preserving edges. The complexity of this method is only a linear function of the number of input image pixels and this thus permits a very fast implementation.

Fang et al. (2011) [4] have discussed a new fast haze removal algorithm from multiple images in uniform bad weather conditions is proposed which bases on the atmospheric scattering model. The basic idea is to establish an over determined system by forming the hazy images and matching images taken in clear days so that the transmission and global airlight can be acquired. The transmission and global airlight solved from the equations are applied to the local hazy area. The discussed algorithm reduces haze effectively and achieves accurate restoration.
He et al. (2011) [5] have proposed a simple but effective image prior dark channel prior to remove haze from a single input image. The dark channel prior is a type of statistics 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 estimation of haze transmission. They can directly evaluate the thickness of the haze using this prior with the haze imaging model and get a high-quality haze-free image. The dark channel prior does not work efficiently when the surface object is similar to the atmospheric light.

Long et al. (2012) [6] have presented a fast and physical-based method. Based on the dark channel prior, they can easily extract the global atmospheric light and roughly estimate the atmospheric veil with the dark channel of the input haze image. Then refine the atmospheric veil using a low-pass Gaussian filter. In most cases, the approach can achieve good results. But, when the images have dense and heterogeneous haze, the results obtained will have color distortion especially in the bright regions and loss of details.

Zhang et al. (2012) [7] have described a new algorithm that is based on an image filtering approach consist of the median filter and uses low-rank technique for the enhancement of visibility. The atmospheric veil is estimated with Monte Carlo simulation and the shortened single value decomposition and the dark channel prior used to restore the haze-free image. This method may not perform well for the scenes with heavy fog and great depth jumps. It also suffers from halo effects.

Xu et al. (2012) [8] have proposed a improved dark channel prior. They studied the dark channel prior and improve this by replacing the time consuming soft-matting part with the fast bilateral filter. This algorithm has a greater efficiency, fast execution speed and improves the original algorithm. Also, the reasons why the dark channel prior leads to dim image after the haze removal, and proposed the improved transmission map formula in order to get the improved visual effects of the image. Traditional algorithm is not suitable for the sky region, so they used weaker method to enhance the flexibility of the improved algorithm.

Ullah et al. (2013) [9] have proposed a single image dehazing technique using improved dark channel prior. The dark channel prior has been further polished. Both chromatic as well achromatic (neutral) features of the image are considered by the proposed model to describe the Dark Channel. Dark Channel prior has been carried by further improving contrast and color vibrancy of restored images. Improved Dark channel take minimum of saturation (1-S) and intensity (I) components instead of RGB components. Refined Dark Channel increases value of restored haze free images. It maintains color reliability and improves the contrast. Somehow it decreases the pixel color saturation.

Hitam et al. (2013) [10] have demonstrated a new technique called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color models that exactly developed for underwater image enhancement. The method operates CLAHE on RGB and HSV color models and both results are combined together using Euclidean norm. The central objective of this method is to moderate significant noise introduced by CLAHE [21] in order to ease a successive process of underwater images. The enhancement method effectively improves the visibility of underwater images.
[4] GAPS IN LITERATURE:

Fog removal algorithms become more beneficial for numerous vision applications. It has been originated that the most of the existing research have mistreated numerous subjects. Following are the various research gaps concluded using the literature survey:-

- The presented methods have neglected the techniques to reduce the noise issue which is presented in the output images of the existing fog removal algorithms.
- Not much effort has focused on the integrated approach of the dark channel prior (DCP) and CLAHE.
- The problem of the uneven illumination is also neglected by the most of the researchers. It degrade the performance of haze removal algorithms
- Not much effort is done towards remote sensing and underwater images.

[5] CONCLUSION

Haze removal algorithms become more useful for many vision applications. It is found that most of the existing researchers have neglected many issues; i.e. no technique is accurate for different kind of circumstances. The survey has shown that the presented methods have neglected the techniques to reduce the noise issue which is presented in the output images of the existing fog removal algorithms. The problem of uneven and over illumination is also an issue for dehazing methods. So it is required to modify the existing methods in such a way that modified technique will work better. In near future to overcome the problems of existing research a new integrated algorithm will be proposed. New algorithm will integrate the dark channel prior, CLAHE and bilateral filter to improve the results further.
REFERENCES


Author[s] brief Introduction

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