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An Efficient Image Haze Removal Algorithm Using Color Attenuation Prior

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Abstract: ***We present a method of recovering high dynamic range radiance maps from photographs taken with conventional imaging equipment. In our method, multiple photographs of the scene are taken with different amounts of exposure. Here proposed scheme states that a simple but powerful color attenuation prior for haze removal from a single input hazy image. Here we create a linear model for modeling the scene depth of the hazy image under this novel prior and learning parameters of the model with a supervised learning process, the depth information can be well recovered. With a depth map of hazy image, we can easily estimate the transmission and restore the scene radiance via the atmospheric scattering model, and thus effectively remove a haze from a single image. Experimental results show that the proposed approach outperforms state-of-the-art haze removal algorithms in terms of both efficiency and the dehazing effect. We discuss how this work is applicable in many areas such as computer graphics we involve digitized photographs, including image-based modeling, image compositing, and image processing. Finally we demonstrate a few applications which is having high dynamic range radiance maps, such as synthesizing realistic motion blur and simulating the response of the human visual system.***

Keywords: Dehazing, defog, image restoration, depth restoration

1. Introduction

Bad weather conditions such as haziness, mist, foggy and smoky degradation in the quality of the outdoor scene. It is annoying problem to photographers because it change the colors and reduces 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. Removing haze from images is an imperative area in image processing. The large quantities of these suspended particles in atmosphere cause scattering of light before it reaches the camera which corrupts the outdoor image quality. Haze attenuates a reflected light from the scenes and blends with additive light in atmosphere. Haze removal techniques tend to improve this reflected light (i.e. scene colors) from mixed light. The constancy and strength of the visual system can also be improved by using this effective haze removal of image. There are various methods available to remove haze from image like polarization independent component analysis and dark channel prior etc.
Visibility restoration (Xu, Zhiyuan et al, 2009) refereed different methods that reduces or remove the deterioration or degradation that have occurred while digital image obtained. The deterioration is because of various factors like relative object-camera motion and blur due to camera misfocus, relative atmospheric violent features and others. We discussing about the degradations due to bad weather such as fog, haze in a image. The Quality of image outdoor scene in a fog and haze weather condition is usually deteriorated by a scattering of a light before it reaches to the camera due to these large quantities of suspended particles (e.g. fog, haze, smoke, impurities) present in the atmosphere. This occurrence influence normal work of automatic monitoring system, outdoor recognition system and smart transportation system. Scattering is caused by two basic phenomena such as attenuation and airlight. Using effective haze or fog removal of image, improves a stability also and robustness of visual system. Haze removal is a very difficult process because fog depends on unknown scene depth information. Fog effect results distance between camera and also an object. Removal of fog requires estimation of airlight map, depth map.

Figure 1: (a) Original image (b) Processed image

The haze removal method is divided in two categories: (a) image enhancement (b) image restoration. The method enhances the contrast of haze image but loses some of information about image.

2. Literature Survey

This section covers the literature from the study of various research papers. Wang, (2010) has explored haze removal from the image depend upon unknown depth information. This algorithm is based on atmospheric scattering of physics-based model. In this on selected region a dark channel prior is applied to obtain a novel estimation of atmospheric light. Th model is based upon some observation on dehaze outdoor image. In non-sky patches, one color channel has very low intensity at some extend of pixels. The low intensity in that region is due to shadows, colorful objects and dark objects etc.

Yu, *et al*. (2011) has proposed novel fast defogging method from a single image based on scattering model. A white balancing is used prior to scattering model for visibility restoration. Then the edge-preserving smoothing approach based on weighted least squares (WLS) optimization framework to smooth the edges of image. Inverse scene albedo is applied for a recovery process. This method does not require prior information.

Shuai, (2012) discussed problems regarding a dark channel of color distortion problem for some light white bright area in the image. The algorithm to estimate a media function in an use of median filtering based on a dark channel was proposed. After making media function more accurate a wiener filtering is applied. Fog restoration problem converted into an optimization problem and by minimizing mean square error , finally fog free image obtained. This algorithm makes hazed image more detailed and the contour smoother, clearer as compare to dark channel prior. This method is a recovery method, combination of statistical characteristics of function and noise.

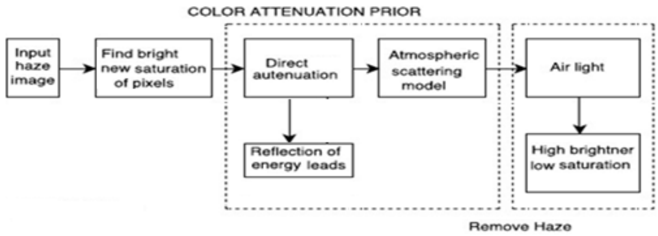
Cheng, et al. in (2012) Proposes a lowest channel prior for image fog removal. This algorithm is simplified from a dark channel prior. It is based upon a key fact that fog-free intensity in a color image has a least value of trichromatic channels. In dark channel prior to estimate the transmission model it performs as a minimum filter for lowest intensity. This filter leads to halo artifacts, especially in the neighborhood of edge pixels. In this algorithm instead of using minimum filter utilises exact O(1) trilateral filter which is based on an raised cosines function to weight value of neighbour of getting fog-free image. The quality of an output image and the cost of computation removing of fog procedure are improved by trilateral filter.

Xu, et al. (2012) recommends a model based on an physical process of imaging in foggy weather. In this model explained a fast haze removal algorithm based on a fast trilateral filtering with dark colors prior . Firstly, an atmospheric scattering model which used for description of the formation of haze image. Then an estimated transmission map is formed using dark channel prior. It combins with gray scale to extract a refined transmission map by usage of fast trilateral filter instead of soft matting. The reason why the image is dim after the use of dark channel prior is observed and a better transmission map formula is proposed to effectively restore the color and contrast of the image, leading to improvement in the visual effects of image.

Sahu, *et al*. (2012) has proposed an algorithm of fog removal from the color image and also useful in hue preserving contrast enhancement of color images. In this method , the original image is converted from RGB to YCbCr (It is the way of encoding RGB information). Y′ is an luma component and C_B is the blue-difference , C_R is red-difference chroma components. Secondly, the intensity component of the converted image and the key observation of all the pixels of image are computed.

3. Proposed Method

In this a novel Dehazing technique is proposed. We had used dark channel prior, Atmospheric light and scene radiance recovery technique are proposed.



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A. Dark Channel Prior

The dark channel prior is based on the following observation on outdoor haze-free images: Most of the non sky patches, one color channel has some part of pixels whose intensity are very low and close to zero. Equivalently, minimum intensity patch is close to zero.

To formally describe this observation, we first define the concept of a dark channel. For an arbitrary image J, its dark Channel Jdark is given by

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

The low intensity in the dark channel is mainly due to three factors: a) shadows, e.g., shadows of cars and buildings, and inside of windows in cityscape images, or the shadows of leaves, trees, rocks in landscape images; b) colorful objects, e.g., any object which is having low reflectance in any color channel (e.g, green grass/tree, red or yellow flower/leaf, and blue water surface) results in low values in the dark channel; c) dark objects or surfaces, e.g., dark tree trunks and stones. Natural outdoor images are colorful and full of shadows, dark channels of these images are really dark!

To verify how good dark channel prior is, we collect an outdoor image set from Flickr.com and several other image search engines using 150 most popular tags annotated by the Flickr users. Haze usually occurs in outdoor landscape as well as cityscape scenes, we manually pick out the haze-free cityscape and landscape ones from each of data set. Besides, we only focus on daytime images. Among them, we randomly select 5,000 images and manually cut out the sky regions. Images are resized so that the maximum of width as well as height is 500 pixels and their dark channels computed using a 15 X 15 patch size.

B. Obtaining Absolute Radiance

For many applications, such as image processing and image compositing, the relative radiance values computed by our method are all that are necessary. If needed, an approximation to the scaling term necessary to convert to absolute radiance can be derived using the ASA of the film8 and the shutter speeds and exposure amounts in the photographs. With these numbers, formulas that give an approximate prediction of film response can be found in [9]. Such an approximation can be adequate for simulating visual artifacts such as glare, and predicting areas of scotopic retinal response. One could recover a scaling factor precisely by photographing a calibration luminaire of known radiance, scaling the radiance values to agree with an known radiance of a luminaire.

C. Estimating the Atmospheric Light

In most of the previous single image methods, the atmospheric light A is estimated from the most haze-opaque pixel. For example, the pixel which is having highest intensity is used the atmospheric light in. But in real images, the brightest pixel could be on a white car or a white building. The dark channel of a haze image approximately the haze denseness well. We uses the dark channel for improving the atmospheric light estimation.First pick the top 0.1% brightest pixels in dark channel. These pixels are most hazeopaque (bounded by yellow lines). Among these pixels, the pixels which is having highest intensity in input image I is selected as a atmospheric light. This simple method based on the dark channel prior is more robust than the ”brightest pixel” method. We use it to automatically estimate the atmospheric lights for all images shown in the paper.

D. Recovering the Scene Radiance

Using the atmospheric light and the transmission map, the scene radiance according to (1) can be recover. But the direct attenuation term J(x) t(x) can be very close to zero when the transmission t(x) is close to zero. The recovered scene radiance J is prone to noise. Hence, we restrict a transmission t(x) by a lower bound t0, i.e.,By preserving a very small amount of haze in very dense haze regions. The scene radiance J(x) is recovered as below,

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

A typical value of t0 is 0.1. The scene radiance is not as bright as the atmospheric light, the image after haze removing looks like a dim. We increases exposure of J(x) for display.

4. Experimental Results

Figure 2: a) Input image

Figure 2: b) Result image

5. Discussions and Conclusions

In this paper, we have proposed a very simple but powerful prior, called dark channel prior, for single image haze removal. Dark channel prior is based on an statistics of the outdoor images. Applying the prior into the haze imaging model, single image haze removal becomes simpler and more effective.

Since the dark channel prior is a kind of statistic, it may not work for some particular images. When scene objects are inherently similar to atmospheric light and therefore no shadow is cast , dark channel prior is invalid. Our method will underestimate the transmission for these objects, such as the white marble in Figure 2. By creating a linear model for the scene depth of the hazy image with this simple but powerful prior and learning the parameters of the model using a supervised learning method, the depth information is recovered. The depth map obtained by this method, we can easily recovered the scene radiance of an hazy image. Experimental results show that the proposed approach achieves dramatically high efficiency and outstanding dehazing effects as well.

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