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Image Dehazing Using Dark Channel Prior

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ABSTRACT: In this paper, we propose a simple but effective image prior - dark channel prior to remove haze from a single input image. The dark channel prior is a kind of statistics of the haze-free outdoor images. It is based on a key observation - most local patches in haze-free outdoor images contain some pixels which have very low intensities in at least one color channel. Using this prior with the haze imaging model, we can directly estimate the thickness of the haze and recover a high quality haze-free image. Results on a variety of outdoor haze images demonstrate the power of the proposed prior. Moreover, a high quality depth map can also be obtained as a by-product of haze removal.

I.INTRODUCTION

Environmental impact such as haze and fog have an unfavorable effect on the image quality. It will be very difficult and challenging to use such images in driver assistance systems, monitoring survelliance systems and outdoor and indoor object detection and recognition which require clear visible and high quality image for further processing. Usually, restoring the degraded hazy images from single input image is pretty challenging and tedious. Haze or fog is a prevalent natural phenomenon created by atmosphere particles that are suspended. Therefore, haze removal is a significant task to restore the visibility in images. There are many problems that need to be addressed in haze removal such as efficient computation of atmospheric air light and transmission depth map. Improved Dark Channel Prior (DCP)[4] is used to improve the transmission depth map construction in our work. The contribution that we introduce focuses on a considerable betterment of the reconstruction module. DCP-based image dehazing technique[2][4] is used to prevent blocking artifacts with enhanced transmission map. It calculates the three transmission maps based on each R, G, B components and one transmission map based on the luminance component of the YCrCb color system. Two images are reconstructed after applying guided filter in transmission map.In this paper, Relativity of Gaussian (RoG)[7] and Guided filter[6] is applied to enhance the transmission depth map for removing the existence of haze. The rest of paper is arranged as following sections. Section 2 outline about the dehazing given in literature. Section 3 deals with atmospheric scattering model. Section 4 illustrates the detailed working of proposed method. Single Image Dehazing based on Improved Dark Channel Prior and Relativity of Gaussian (RoG) method, Section 5 and 6 gives an results and assessment metrics of the proposed method, Section 7 deals with the conclusion and the summarizes the contributions.

Haze removal1 (or dehazing) is highly desired in both consumer/computational photography and computer vision applications. First, removing haze can significantly increase the visibility of the scene and correct the color shift caused by the airlight. In general, the haze-free image is more visually pleasing. Second, most computer vision algorithms, from low-level image analysis to high-level object recognition, usually assume that the input image (after radiometric calibration) is the scene radiance. The performance of vision algorithms (e.g., feature detection, filtering, and photometric analysis) will inevitably suffer from the biased, low-contrast scene radiance. Last, the haze removal can produce depth information and benefit many vision algorithms and advanced image editing. Haze or fog can be a useful depth clue for scene understanding. The bad haze image can be put to good use.

However, haze removal is a challenging problem because the haze is dependent on the unknown depth information. The problem is under-constrained if the input is only a single haze image. Therefore, many methods have been proposed by using multiple images or additional information. Polarization based methods [14, 15] remove the haze effect through two or more images taken with different degrees of polarization. In [8, 10, 12], more constraints are obtained from multiple images of the same scene under different weather conditions. Depth based methods [5, 11] require the rough depth information either from the user inputs or from known 3D models.

Figure 1: Hazed image and Dehazed image

II.LITERATURE REVIEW

This section provides a comprehensive overview of distinct techniques for removing single image haze. Extensive research has been conducted in the field of haze detection and visibility improvement in hazy scenarios. We have single image haze removal and multiple image haze elimination techniques in the literature. In the, work we concentrate on eliminating haze from a single image Purging haze from multiple images is time consuming and computationally intensive. Elimination of haze from single image is simple and easy to manipulate. Currently most of the haze removal tasks are done using CNN based techniques. Ren et al [12] proposed a deep learning approach on multi-scale CNN (MSCNN) technique for the haze elimination. Cai et al [13] investigated a deep CNN technique DehazeNet which significantly improves the haze elimination process thereby obtaining better hazeless images.

In existing method[4], the technique of image dehazing is discussed based on the dark channel (DCP)[2]. Existing image dehazing techniques using traditional DCP can be improved or enhanced for image dehazing task. The experimental result shows that the existing method produces over contrast and edges are not properly identified. In such case, a method is introduced which rise above the inadequacy of the existing method.

The transmission t in a local patch is estimated by maximizing the visibility of the patch and satisfying a constraint that the intensity of J(x) is less than the intensity of A. An MRF model is used to further regularize the result. This approach is able to unveil details and structures from the haze image. However, the output images tend to have larger saturation values because this method solely focuses on the enhancement of the visibility and does not intend to physically recover the scene radiance. Besides, the result may contain halo effects near the depth discontinuities.

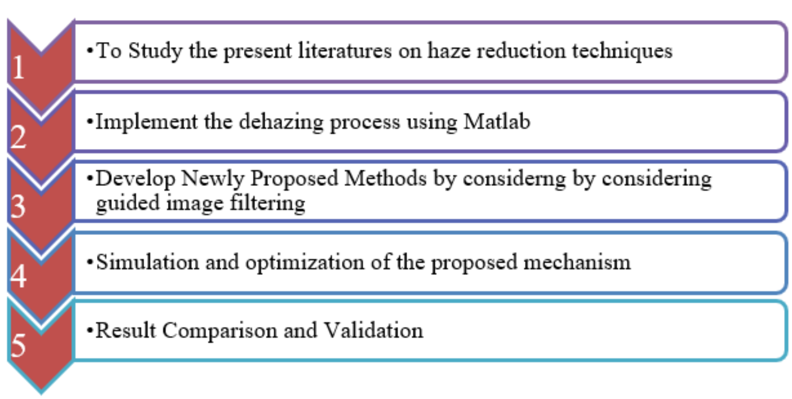
In [2], Fattal proposes an approach based on Independent Component Analysis (ICA). First, the albedo of a local patch is assumed as a constant vector R. Thus, all the J(x) in the patch have the same direction R, . Second, by assuming that the statistics of the surface shading _J(x)_ and the transmission t(x) are independent in the patch, the direction of R can be estimated by ICA. Finally, an MRF model guided by the input color image is applied to extrapolate the solution to the whole image. This approach is physics-based and can produce a natural haze-free image together with a good depth map. However, because this approach is based on a statistically independent assumption in a local patch, it requires the independent components varying significantly. Any lack of variation or low signal-to-noise ratio (e.g., in dense haze region) will make the statistics unreliable. Moreover, as the statistics is based on color information, it is invalid for

Author	Dehazing based on	Method	Advantage
Salazar et.al[3]	Algorithm using Morphological Operations	Morphological Operations used to identify the features of shape of object	Fast Computing of transmission depth map
Kaiming He et.al[6]	Using Dark channel prior	Dark channel prior is based on the estimation of dark pixels which helps in computing transmission of haze.	Construct transmission depth map directly from hazy outdoor images
Tufail et.al[4]	Improved Dark Channel Prior from color models RGB and YCbCr .	Transmission maps are computed for RGB channels and luminance channel in YCbCr	Better scene visiblity
Tsung et.al[5]	Airlight Correction and filters applied	Airlight White Correction performed and filters based on local light and prespective prior applied	Better visual quality, helps in removing color casts.

grayscale images and difficult to handle dense haze which is often colorless and prone to noise.

III.METHODOLOGY OF PROPOSED

The proposed method concentrates on detailed enhancement of the transmission map and hence reconstructing the hazeless image. Existing method [4] suffers from lack of proper reconstruction of the haze free image. To solve these issues, RoG is applied on the guided filter and improved dark channel prior is computed on the hazy image in our work. The existing method only performs the refinement of transmission map using laplacian filter and the images contain excess contrast and some edges are not properly identified. The DCP is calculated by taking the advantages of both the color system i.e, RGB and Y channel of YCbCr color system. The influence of the airlight can be computed with the concept of Dark channel prior estimation. After the estimation of air light, compute the transmission map using air light from RGB channels and air light from YCbCr, it can be denoted as A and Ay respectively. Transmission map enhancement is done using RoG [7][8]. We compute the RoG for RGB and YCbCr color space to produce guidance image. Both guidance images are added to a guided filter for smoothening to generate t'(x) and t'y(x). In the reconstruction step, two images thus obtained are incorporated to restore and reconstruct the hazeless image. A new technique is introduced in this work to enhance the transmission depth map and used Relativity of Gaussian (RoG) and Guided filter for detailed enhancement in the no haze images.



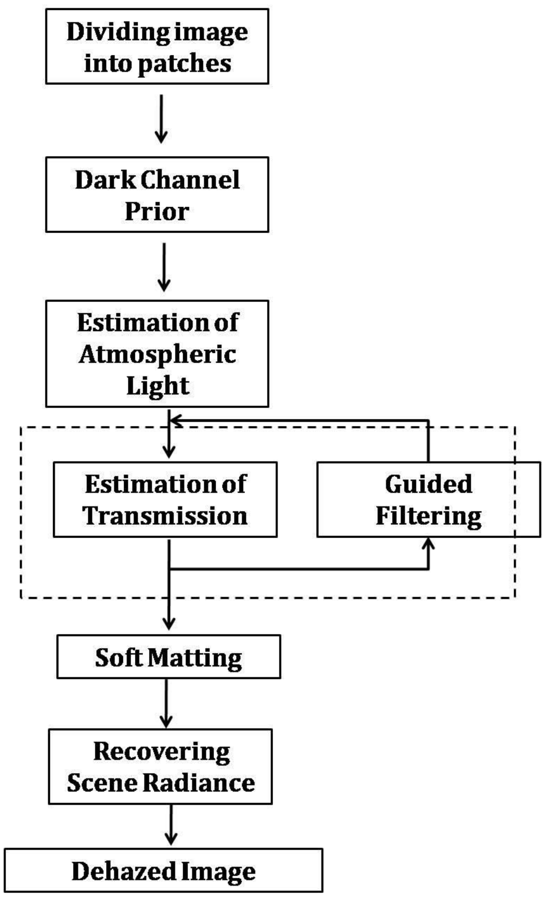


Figure 2: **Dehazing process**

This thesis work's goal is to provide a technique for aze removal in digital images:

- To develop a model for dehazing process
- To develop mathematical model for haze reduction
- To determine the parameters' ideal values for greater haze reduction
- To assess the effectiveness of the suggested approach.
- To evaluate the precision of the proposed model with previous methods

IV. RESULTS AND DISCUSSION

Colores et.al[3] result is haze free but it's color contrast is high and edges are not clear as in the reference image. Images obtained from the proposed method. From the qualitative assessment, it is clear that the result of the proposed method appear to be realistic ,visually pleasing and almost similar to the ground truth image.

The different evaluation measures employed to compute the performance of the proposed algorithm are SSIM, PSNR, BRISQUE and NIQE. We have performed the quantitative analysis in two ways. In the first case, test is conducted with the images where reference images or ground truth images are available and in the second case, where the reference images are not known or available. The metrics SSIM and PSNR are computed for the hazy images where reference image is available whereas BRISQUE and NIQE is computed for the images where ground truth images are not present .In both the above said cases, proposed technique outperform the existing method.

In our experiments, we perform the local min operator using Marcel van Herk's fast algorithm [17] whose complexity is linear to image size. The patch size is set to 15 × 15 for a 600 × 400 image. In the soft matting, we use Preconditioned Conjugate Gradient (PCG) algorithm as our solver. It takes about 10-20 seconds to process a 600×400 pixel image on a PC with a 3.0 GHz Intel Pentium 4 Processor. our haze removal results and the recovered depth maps. The depth maps are computed using Equation (2) and are up to an unknown scaling parameter β. The atmospheric lights in these images are automatically estimated using the method described in Section. As can be seen, our approach can unveil the details and recover vivid color information even in very dense haze regions. The estimated depth maps are sharp and consistent with the input images.

Figure 3 : Results of Image Dehazing Using Dark Channel Prior

V.CONCLUSION AND FUTURE

Usually the natural weather conditions such as haze or fog hinder the visibility and aesthetic view of a scene. An improved image dehazing system has been proposed exploring the concept of improved Dark Channel Prior (DCP) and Relativity of Guassian (RoG) with guided filter. Results show that the existing method produces over contrast, over enhancement and detailed information is hidden and is not properly identified. So this improved method calculates the transmission map and applied Relativity of Gaussian and Guided filter to enhance the transmission map. This work provides good performance for the task of obtaining hazeless image both qualitative and quantitative manner. Experimental results show that the proposed method estimates haze more accurately, the reconstruct the images are more realistic and detailed information is restored.

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