Visibility Restoration of Single Hazy Images Captured in Real-World Weather Conditions

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Abstract -*AVisibility restoration is very important in the field of computer vision applications such as outdoor object recognition systems, obstacle detection systems, video surveillance systems, and intelligent transportation systems. The visibility of outdoor images is often degraded due to the presence of haze, fog, sandstorms, and so on. Poor visibility caused by atmospheric phenomena causes failure in computer vision applications. In order to solve this problem, visibility restoration (VR) techniques have been developed. This paper proposes a novel VR method that uses a combination of three major modules: a depth estimation (DE) module; a color analysis (CA) module; and a Visibility Restoration (VR) module. The proposed DE module takes advantage of the median filter technique and adopts our adaptive gamma correction technique. The CA module is based on the gray world assumption and analyzes the color characteristics of the input hazy image. The VR module uses the adjusted transmission map and the color-correlated information torepair the color distortion in variable scenes captured during inclement weather conditions. This is one of the best method while comparing with the previous state of the art methods.*

Key Words:—**Bad weather, dark channel prior, haze, Gray World Assumption ,visibility restoration (VR).**

1.INTRODUCTION

Visibility restoration refers to different methods that aim to reduce or remove the degradation that have occurred while the digital image was being obtained. The degradation may be due to various factors like relative object-camera motion, blur due to camera misfocus, relative atmospheric turbulence and others. This method discussing about the degradations due to bad weather such as fog, haze, sand storm and snow in an image. The image quality of outdoor screen in the fog and haze weather condition is usually degraded by the scattering of a light before reaching the camera due to these large quantities of suspended particles in the atmosphere. This phenomenon affects the normal work of automatic monitoring system, outdoor recognition system and intelligent transportation system. Scattering is caused by two fundamental phenomena such as attenuation and airlight. By the usage of effective haze removal of image, improve the stability and robustness of the visual system.

Various haze removal techniques have been proposed to improve the visibility of degraded images. Additional information approaches, multiple image approaches and single image approaches are the major categories of haze removal techniques. The efficiency of haze removal may change in response to varied weather conditions and scene objects in realistic environments. In particular, some methods cannot adequately deal with color distortions and complex structures. In these situations, restored images will feature color shift and artifact effects.

In order to solve this problem, Visibility Restoration (VR) techniques have been developed and play an important role in many computer vision applications that operate in various weather conditions. This paper proposes a novel VR method that uses a combination of three major modules .

- Depth Estimation module that is based primarily on the dark channel prior technique and is used to directly estimate the transmission map of a hazy image. However, two prominent problems exist in regard to the dark channel prior technique: generation of halo effects and insufficient transmission map estimation. The Depth Estimation module circumvents these problems using a refined transmissionprocedure and an enhanced transmission procedure.
- Color analysis (CA) module uses the gray world assumption to analyze the color characteristics of input images. The obtained color information can express the variation range of RGB distribution and thereby circumvent color distortion problems. Color Analysis module that uses the gray world assumption to determine whether or not the average intensities of the each color

channel are equal. After operation of the DE and CA modules, effectively recover a hazy image removed by atmospheric particles.

- Visibility restoration module uses the adjusted transmission map and color-correlated information produced, respectively, by the DE and CA modules to recover a high-quality haze-free image.

This paper is organized as follows. section 2 presents some related work and recent studies on visibility restoration techniques. Section 3 presents a detailed description of our proposed haze removal method. Section 4 presents and contrast the experimental results. Finally the conclusion is presented in section 5.

2. Related works

Z.-Y. L. Cheng-Hung Chuang, Wei-Chih Shen *et al.* [1] proposed a method can be briefly summarized in three principal steps, i.e. image segmentation, foreground and background classification, and depth estimation. The aim of image segmentation is to extract different objects or regions in one image. Then foreground and background are detected and classified from the segmented objects or regions. Foreground and background are the essential factors to let human eyes perceive stereo vision. Finally, according to the depth cues, the depth map is estimated and created from a single outdoor image.

Y. D. Wei Zhou and R. He *et al.* [2]proposes and aims at estimating 3D depth from a single image, is a challenging task in computer vision since a single image does not provide any depth cue itself. Machine learning-based methods transfer depth from a pool of images with available depth maps to query image in parametric and non-parametric manners. However, these methods generally involve processing a large dataset, therefore are rather time-consuming. First, we evaluate the similarities of images using feature extraction based methods; then, based on these similarities, the large RGB-D image set is partitioned into several groups via efficient clustering approaches such as K-means and the Affinity Propagation; consequently, the input query image is only compared with each cluster's representative image and regard the group containing the most similar image as the final training dataset.

G. F. N.M. Kwoka, D. Wanga and Q.P *et al.* [3] proposed and developed an approach for color correction based on a modified implementation of the gray world assumption. The image color is adjusted by employing a gamma correction to satisfy the gray world assumption and avoid color saturation as encountered in the conventional approach. In order to further improve the image visual quality, an intensity preservation criterion is adopted as an additional means to produce the resultant image. With the normalization of intensity in accordance with the original image, an enhanced image both in color and intensity, is finally obtained.

Z. Lu *et al.*[4]proposed an improved method by OTSU threshold, which quickly distinguishes the background and foreground and also improves the performance by applying Gray World Assumption (GW) under the condition of considering the weight of background and foreground. With the higher image quality requirement for digital camera, image process algorithm becomes more efficient and cheaper choice to improve camera technology. One of most important image process algorithms is automatic white balance (AWB), which can make pictures look normal, even under different illumination.

J.-Y. S. Jin-Hwan Kim and C.-S. Kim *et al.* [5] propose and present a physics-based model that describes the appearances of scenes in uniform bad weather conditions. Changes in intensities of scene points under different weather conditions provide simple constraints to detect depth discontinuities in the scene and also to compute scene structure. Then, a fast algorithm to restore scene contrast is presented. All the methods described in this paper are effective under a wide range of weather conditions including haze, mist, fog, and conditions arising due to other aerosols. Further, this methods can be applied to gray scale, RGB color, multispectral and even IR images. We also extend our techniques to restore contrast of scenes with moving objects, captured using a video camera. This paper addressed the problem of restoring the contrast of atmospherically degraded images and video. We presented methods to locate depth discontinuities and to compute structure of a scene, from two images captured under different weather conditions. Using either depth segmentation or scene structure, Then showed how to restore contrast from any image of the scene taken in bad weather. Advantages This methods can be applied to images captured using multispectral cameras, IR cameras, and the usual broadband RGB and gray-scale cameras.

Z. Z. Sun Kang, Wang Bo *et al.*[6] propose and present a simple but efficient iterative method for increasing scene visibility and recovering haze-free scene contrast from a single hazy image. Using the dark channel prior with the haze imaging model, directly estimate the coarse transmission map at first, then an iterative refinement module based on bilateral filter is applied to refine the transmission map. Firstly, directly estimate the coarse transmission map by taking advantage of dark channel prior and take it as the initial transmission map. And then, follows an iterative refinement module. Next, a cost volume is built based on the current transmission map, and a fast bilateral filtering is performed throughout each slice of the cost volume to produce the new cost volume.

The refined transmission map is generated based on this cost volume by selecting the depth hypothesis with the minimal cost at first and sub-pixel estimation afterwards.

3. PROPOSED METHOD

The quality of photograph in our daily life is easily undetermined by the aerosols suspended in the medium, such as dust, mist, or fumes. This has an effect on the image, Such degraded photographs often lack visual vividness and offer a poor visibility of the scene contents. The goal of haze removal algorithms is to enhance and recover the detail of the scene from haze image. There are many circumstances that accurate haze removal algorithms are needed. In computer vision, most automatic systems for surveillance, intelligent vehicles, object recognition, etc., assume that the input images have clear visibility. However, this is not always true in bad weather. In consumer photography, the presence of fog will be an annoyance to the images for it reduces the contrast significantly. In aerial photography and satellite remote sensing, the photos are much more easily plagued by aerosols. Visibility Restoration approach in order to restore hazy images captured during inclement weather conditions, such as haze, fog, sandstorms, and so on. Our approach involves three important modules:

- Depth Estimation module.
- Color Analysis module.
- Visibility Restoration module.

Initially, the proposed DE module designs an effective refined transmission procedure that takes advantage of the median filter to preserve edge information and thereby avoid generation of block artifacts in the restored image. This is followed by a transmission enhancement procedure, which adjusts the intensity of the transmission map to achieve optimum haze removal results. After these two procedures are accomplished by the DE module, effective depth information can be obtained. Next, in order to recover true color, the color characteristics and color information of the input hazy image are, respectively, analysed and acquired in the proposed CA module. Finally, the VR module recovers a high-quality haze-free image using the depth and color-correlated information to adequately conceal the atmospheric particles present in various real-world weather conditions.

DE module that is based primarily on the dark channel prior technique and is used to directly estimate the transmission map of a hazy image. However, as mentioned in the previous section, two prominent problems exist in regard to the dark channel prior technique: generation of halo effects and insufficient transmission map estimation. The DE module circumvents these problems using a refined transmission procedure and an enhanced transmission procedure.

CA module uses the gray world assumption to determine whether or not the average intensities of the each color channel are equal. The average intensities of the red, green, and blue channels are calculated where the size of the observed image is MN pixels. The color difference value for the red, green, and blue channels is calculated using the average intensity of each color channel.

VR module uses the adjusted transmission map and color correlated information produced, respectively by the DE and CA modules to recover a high quality haze free image. Hence we obtained a haze free image in an effective way. The flow chart of the proposed algorithm is shown Fig.1.

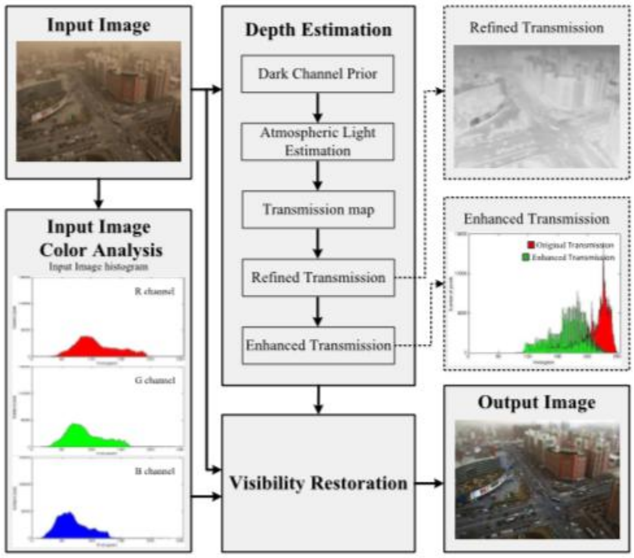

Fig 1. Proposed method

4 EXPERIMENTAL RESULTS

An input hazy image is read and our proposed frame work is applied. For getting good results, it is needed to tune the patch size into some values. Fig 2. shows an example input image and result using our method.

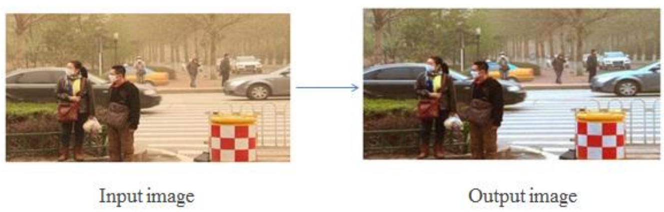

Fig 2. Result by our method

The experimental works contains four major parts: 1) refined transmission results; 2) enhanced transmission results; 3) results of haze removal under varied weather conditions; and 4) quantitative evaluation. The first part focuses on the advantages of the refined transmission map and the results of haze removal in images, which have complex structures. The second part describes the benefits of the enhanced transmission

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procedure,which is used to ensure sufficient transmission map estimation. The third part presents the results of VR for images featuring different scenes captured under varied weather conditions. The purpose of the final part is to provide quantitative evaluation of images captured under varied weather conditions. Fig 3. Shows the refined transmission results of previous method and proposed methods. The comparison of enhanced transmission results of previous methods and proposed method are given in the Fig 4. The result of haze removal under varied weather conditions are shown in the Fig.5.1 and Fig 5.2.

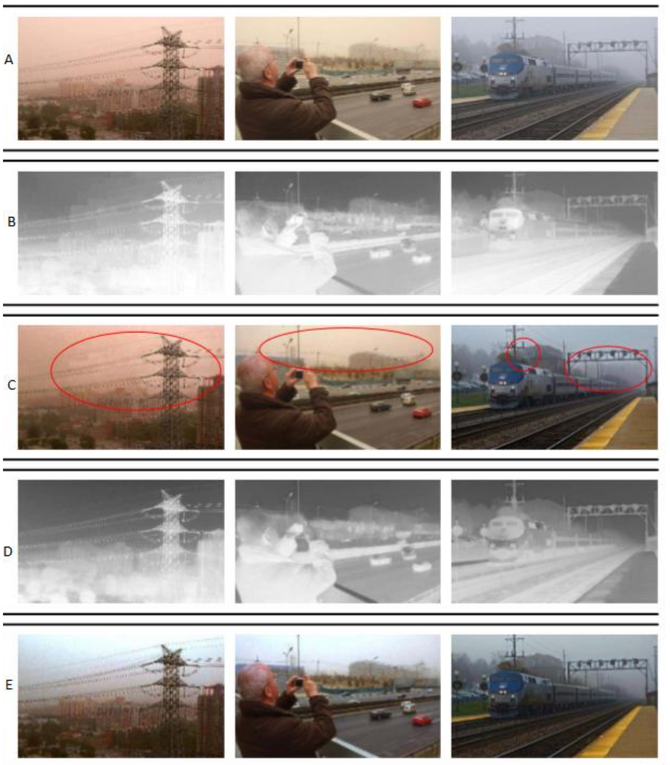

Fig 3. refined transmission results (A.Input haze image; B.previous transmission approach; C.result by previous approach; D.transmission by our approach; E.our result)

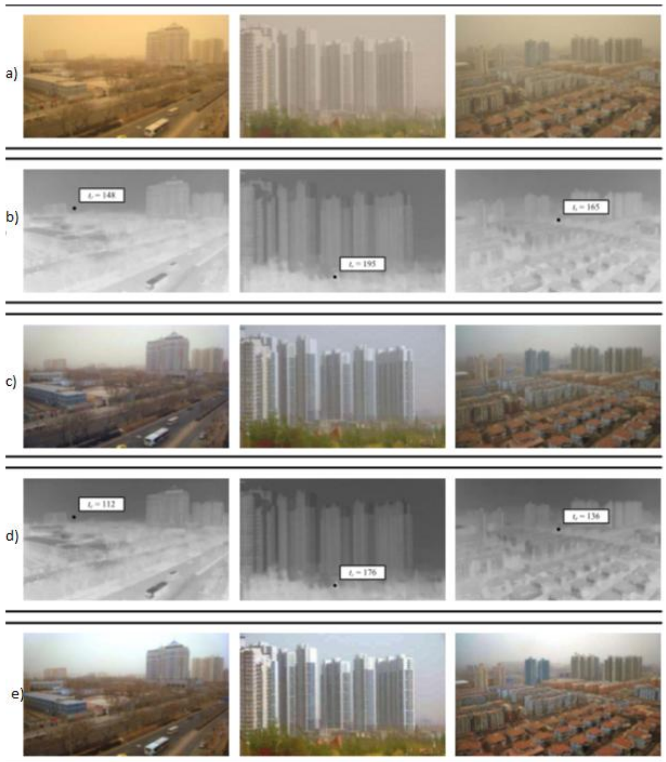

Fig 4. Enhanced transmission results (a)input haze image; b)transmission map without enhanced transmission ; c) result without enhanced transmission; d)transmission map with enhaced transmission; e) result with enhanced transmission)

Results of haze removal under varied weather conditions part make a comparison of our method and result with previous method. Ther are two primary categories, results for input images without color distortion and results for input images with color distortion.

Fig 5.1 Results for input images without color distortion (a.foggy image without colour distortion ; b.recovered image produced by previous method ; c.recovered image by our method)

Fig 5.2 Results for input images with color distortion (a. a sand storm image with colour distortion ; b.recovered image produced by previous method ; c.recovered image by our method)

4.1 Quantitative Evaluation

Test image is analysing by checking the size of the input image. The proposed DE module designs an effective refined transmission procedure that takes advantage of the median filter to preserve edge information and thereby avoid generation of block artifacts in the restored image. This is followed by a transmission enhancement procedure, which adjusts the intensity of the transmission map to achieve optimum haze removal results. After these two procedures are accomplished by the DE module, effective depth information can be obtained. Next, in order to recover true color, the color characteristics and color information of the input hazy image are, respectively, analysed and acquired in the proposed CA module. Finally, the VR module recovers a highquality haze-free image using the depth and color-correlated information to adequately conceal the atmospheric particles present in various real-world weather conditions.

5 CONCLUSION

Propose a novel VR approach for images captured in varied weather conditions and featuring variable scenes. The proposed approach uses a combination of three major modules, Depth Estimation module, Color Analysis module and Visibility Restoration module. First, the proposed DE module applies a refined transmission procedure to avoid the generation of block artifacts in the restored image using the median filter to preserve the edge information of the image. Subsequently, an effective transmission map is estimated by adjusting its intensity via an enhanced transmission procedure based on the adaptive gamma correction technique. Next, the proposed CA module uses the gray world assumption to analyze the color characteristics of the input haze image. The obtained color information can be adapted for various weather conditions, including haze, fog, and sandstorms. Finally, the VR module can effectively restore the visibility of input images and obtain high-quality haze-free results via the DE module and the CA module. Proposed VR approach not only effectively circumvent significant problems regarding color distortion and complex structure, but it can also produce high-quality haze- free images more effectively than other methods.

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