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

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Abstract: The visibility of outdoor images captured in inclement weather is often degraded due to the presence of haze, fog, sandstorms, and so on. Poor visibility caused by atmospheric phenomena in turn causes failure in computer vision applications, such as outdoor object recognition systems, obstacle detection systems, video surveillance systems, and intelligent transportation systems. In order to solve this problem, visibility restoration techniques have been developed and play an important role in many computer vision applications that operate in various weather conditions. However, removing haze from a single image with a complex structure and color distortion is a difficult task for visibility restoration techniques. This paper proposes a novel visibility restoration method that uses a combination of three major modules: a depth estimation module, a color analysis module, and a visibility restoration module. The proposed depth estimation module takes advantage of the median filter technique and adopts our adaptive gamma correction technique. By doing so, halo effects can be avoided in images with complex structures and effective transmission map estimation can be achieved. The proposed color analysis module is based on the gray world assumption and analyzes the color characteristics of the input hazy image. Subsequently, the visibility restoration module uses the adjusted transmission map and the color-correlated information to repair the color distortion in variable scenes captured during inclement weather conditions. The experimental results demonstrate that our proposed method provides superior haze removal in comparison to the previous state-of-the-art method through qualitative and quantitative evaluations of different scenes captured during various weather conditions.

Keywords: High-Resolution (HR), RGB, Low-Resolution (LR).

I. INTRODUCTION

These methods recover the contrast of weather-degraded input images using appropriate prior information or assumptions. All these current approaches fail when the image mismatches their prior or assumption. The main disadvantage of these algorithms is their time consumption. Average time taken for a 600 x 400 image is around 30-40 seconds, 10-20 seconds and 5-7 minutes in respectively. They proposed a fast algorithm for visibility restoration from a single image.

Problem 1: Halo Effects: According to the recovered image may become oversaturated when the dark channel prior uses a small patch size. For the reasons adopt a patch size of 15 X 15 to avoid oversaturation of recovered images. However, using a patch size of 15 X 15 in the dark channel prior will cause the recovered image to contain halo artifacts along depth discontinuities. Therefore, He et al. apply the soft matting technique to refine the transmission map and reduce the propensity for generation of halo effects in the recovered image.

Problem 2: Color Distortion: In their previous study, He et al. propose a haze removal method to recover the original scene radiance by using the same restoration for each color channel. It is assumed that each color channel of the input image has a similar distribution in its RGB color histogram. Nonetheless, different regions of the world have varied weather conditions, which may lead to serious color distortion problems in captured images. For example, a sandstorm in the Beijing area results in the blue hue of the spectrum becoming largely absorbed by atmospheric particles. This will lead to a captured image featuring prominent yellow and orange haze. Thus, the captured sandstorm images will always have different color distributions in their RGB color histograms. However, the dark channel prior assumes that the color channel of the input image has a similar histogram distribution under different conditions, such as fog.

Problem 3: Insufficient Transmission Map Estimation: The main principle of the haze removal technique of is predicated upon using the dark channel prior to estimate the transmission map, which in turn depends on the minimum value of the RGB color channel in the input image. Basically, a lower intensity of the dark channel signifies thinner haze in the corresponding area; conversely, a higher intensity in the dark channel signifies thicker haze. However, in the sandstorm image, the blue hue of the spectrum is largely absorbed by atmospheric particles and the histogram of the dark channel prior is very close in shape to the histogram of the blue channel. For this reason, the dark channel prior based on a minimum operator usually shows...
lower intensity in sandstorm images due to the lessened intensity of the blue channel. Thus, in images of major sandstorms, the dark channel prior method will often perceive less haze than that which actually exists.

II. LITERATURE SURVEY
Color Constancy Using Natural Image Statistics and Scene Semantics: The methods are all based on specific assumptions such as the spatial and spectral characteristics of images[1]. In general, color constancy algorithms can be divided into two groups. The first group consists of algorithms based on low level image features that can be directly applied to images. The second group consists of algorithms that use information acquired in a learning phase to obtain knowledge about the images, like possible light sources and the distribution of possible reflectance colors to be present in natural scenes. This algorithm is based on the assumption that in real-world images, for a given illuminant, only a limited number of colors can be observed. Using this assumption, the illuminant can be estimated by comparing the distribution of colors in the current image to a distribution of colors. For instance, the Gray-World algorithm assumes that the average color in a scene taken under a neutral light source is achromatic, while the Gray-Edge algorithm assumes that the average edge is achromatic. This means that the set of possible adjacent color values (i.e., color edges) in real-world images is more restricted than the set of possible pixel values. Hence, the use of local spatial information will provide more stable gamuts than pixel values to compute color constancy.

Furthermore, a higher accuracy is obtained when there are a large variety of edges in a scene. Hence, color constancy methods are largely dependent on the distribution of colors and color edges in an image. Comparing the median angular error of this algorithm having, an increase of nearly 20 percent can be obtained when the circumstances under which the algorithm will be used are known a priori.

Edge-Preserving Decompositions for Multi-Scale Tone and Detail Manipulation Many recent computational photography techniques decompose an image into a piecewise smooth base layer, containing large scale variations in intensity, and a residual detail layer capturing the smaller scale details in the image[10]. Using edge-preserving operator Based on weighted least squares framework and Used to reduction ringing in deblurring images in noise and Using smoothing propagation of sparse constraints and Well-suited for coarsening of image and also Extraction of detail at various spatial scales. It has two layers Base layer and detail layer. Base layer is the larger scale variations in intensity and Applying edge-preserving smoothing operator in image. Detail layer has the difference between original image and base layer the problem is decrease in preserve edges. While manually adjusting the saturation alleviates the problem, a more principled solution is needed. Applications to edge-preserving operator are Tone mapping, Detail enhancement, Contrast manipulation.

A. Single Image Haze Removal Using Dark Channel Prior
It is based on the statistics of outdoor haze free images in hazy images; the intensity of these dark pixels in that channel is mainly contributed by the air light. Therefore, these dark pixels can directly provide an accurate estimation of the haze transmission. Combining a haze imaging model and a soft matting interpolation method, recover a high quality haze free image and produce a good depth map. For example the low intensity in the dark channel is mainly due to three factors like a) shadows, e.g., the shadows of cars, buildings, and the inside of windows in cityscape images, or the shadows of leaves, trees, and rocks in landscape images) b) colorful objects or surfaces) dark objects or surfaces, e.g., dark tree trunks and stones. Dark channel is computed on square neighbour hoods. Block artifacts and halos are reduced by using a soft matting algorithm. Advantages: simple but powerful, bad haze image can be put to good use and Disadvantages: Invalid when the scene objects are inherently similar to the atmospheric light and no shadow is cast on them. It is designed to remove spatially invariant haze, when the depth of the image is not constant it can only remove a thin haze layer corresponding to the nearest objects. The dark channel prior is based on the statistics of outdoor haze-free images. Combining the prior with the haze imaging model, single image haze removal becomes simpler and more effective. Since the dark channel prior is a kind of statistics, it may not work for some particular images. When the scene objects are inherently similar to the atmospheric light and no shadow is cast on them. This method is failed to recover the true scene radiance of the distant objects and they remain bluish.

III. EXISTING SYSTEM
Haze removal techniques belonging to the multiple image approaches category employ two or more images to estimate scene depth and subsequently remove haze formation. Schechner et al. proposed a method which uses two or more images of the same scene with different polarization degrees produced by rotation of a polarizing filter to compute scene depth and recover the vivid color of captured images. Methods proposed by Narasimhan et al estimate scene depth and then remove haze by comparing two images that are captured under different weather conditions. However, the above haze removal methods using multiple images usually require additional expense or hardware in order to perform effectively. Recently, research has focused on single image haze removal techniques which use strong assumptions or priors. Tan proposed a method which restores hazy images via a single input image by maximizing the local contrast of the image based on an observation that haze-free images possess higher contrast than input hazy images. This method can produce acceptable results, yet restored images may contain some block artifacts near depth discontinuities. The approach ofFatal removes the haze by estimating the albedo.
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of a scene and deducing the transmission medium from a single input image based on the assumption that transmission and surface shading are locally uncorrelated. However, this method may fail when input images contain dense haze. He et al. proposed a method which uses a key assumption that most local patches for outdoor haze-free images exhibit very low intensity in at least one of color channel, which can be used to directly estimate haze density and recover vivid colors.

Disadvantages of Existing System: The following form of the superresolution problem is considered: A high-resolution (HR) image is degraded by a blurring filter, representing (for example) the PSF of an optical sensor. It is subsequently subsampled. Noise is then additively mixed with the blurred and subsampled image to create the available low-resolution (LR) image.

IV. PROPOSED SYSTEM

Currently, the method of He et al. is generally considered to be the best single image haze removal approach. However, the efficacy of haze removal may change in response to varied weather conditions and scene objects in realistic environments. In particular, the method proposed by The et al. cannot adequately deal with color distortions and complex structures. In these situations, restored images will feature color shift and artifact effects. Therefore, we propose a novel visibility restoration approach based on the conjunctive utilization of the median filter operation, the adaptive gamma correction technique, the gray world assumption, and the dark channel prior method. The key features of our proposed method are organized into three proposed modules as follows:

- In order to avoid generation of halo effects and insufficient estimation of the transmission map, the proposed depth estimation module contains two major procedures which take advantage of the median filter to preserve edge information. The adaptive gamma correction technique is employed to adjust the intensity of the transmission map.
- Next, the proposed color analysis 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.
- The proposed visibility restoration module uses the adjusted transmission map and color-correlated information produced respectively by the depth estimation and color analysis modules to recover a high-quality haze-free image. Our method was proven effective by qualitative and quantitative comparisons of the results produced by our method to those produced by the method of He et al. for several realistic scenes captured under varied weather conditions.

V. CONTEXT DIAGRAM OF PROJECT

Fig. 1. context diagram of visibility restoration.

A. Existing Output

Fig. 2. Existing Output.

When the following methods are applied to images that are comprised of stochastic textures, they do not yield the desired results as shown in Fig. 2.

- Enhancement Techniques
- Texture Representation and Enhancement
- Stochastic Textures
1. Enhancement Techniques: Image enhancement algorithms, used in deblurring and denoising methods, generally attempt to solve the following inverse problem for a degraded image: a possible solution is a blurring kernel. When these methods are applied to images that are comprised of stochastic textures, they do not yield the desired results. This is due to the common assumption that low gradient areas in an image are originated by noise or optimization artifacts (such as ringing or aliasing) and not by a valuable texture.

2. Texture Representation and Enhancement: Textures, in general, can be divided into two main types: Regular, or structured, and stochastic. One can define the former as spatially-replicated instances of a single or several repetitive patterns. An example of a regular texture is a brick wall. To compare with, stochastic textures do not contain a specific pattern. Instead, they are considered to be realizations of random processes. This type of textures cannot be modelled in a similar manner to regular textures. The texture spectrum, as defined in, contains textures in varying complexity and regularity. As the two types of textures are visually and conceptually different, different techniques are used in order to enhance them. Most of the effort in texture enhancement has been devoted, even inadvertently, to the regular textures. Regular textures contain replicated versions of a single or a few basic patterns, in varying amounts of distortion.

3. Stochastic Textures: A different approach for regular and stochastic texture enhancement is the texture synthesis, in which a sample patch is used in order to create a newly formed image of larger size and the same visual appearance as the original. While such methods show successful results in visual resemblance to the original, they are less effective in deconvolution problems such as superresolution, in which a high resolution estimate has to represent the input low resolution image.

B. Proposed Output

To overcome the existing methods, we are using Super-Resolution (SR) methods of the following:
- Anisotropic Diffusion
- Texture-Based Tensor Diffusion
- Tensor Diffusion

Anisotropic Diffusion: A brief review of the anisotropic diffusion that will suffice for our application is provided. This diffusion, although commonly referred to anisotropic, is in fact non-linear but isotropic. This has been noted by Weickert, who introduced a truly anisotropic diffusion process, commonly referred to as tensor diffusion: This formulation allows for different types of diffusion to be performed in different orientations within the image. In edge enhancing diffusion, for instance, only the diffusion coefficient perpendicular to the edge orientation will assume a significant value. This method further emphasizes edges while smoothing noisy image areas. Instead of a single diffusivity function, two functions are used - one for each eigenvalue.

Texture-Based Tensor Diffusion: One cannot expect to represent a natural texture using a single parameter. Instead of using a general function, we use a structure function generated from the degraded image itself. This yields an image which contains the details of the degraded image, along with correlations introduced according to the specific structure of the non-stationary field. We refer to the structure function derived from the degraded image as the empirical structure function (ESF). The method to recover the ESF from a given, degraded, image is based on an inverse procedure to the method of obtaining the image from the structure function. Using the ESF, it is possible to obtain an
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image, from the degraded image, by calculating the autocorrelation of the first- and second-order increments, solving the LS problem is to obtain a structure function and using the synthesis algorithm. The resulting image is referred to as the empirical image.

Tensor Diffusion: We now consider the modifications required to enable the tensor diffusion to perform superresolution on natural textures. This allows for the introduction of missing texture details, while still emphasizing the edges of a degraded texture image.

Median Filter: Median filtering is one kind of smoothing technique, as is linear Gaussian filtering. All smoothing techniques are effective at removing noise in smooth patches or smooth regions of a signal, but adversely affect edges. Often though, at the same time as reducing the noise in a signal, it is important to preserve the edges. Edges are of critical importance to the visual appearance of images. For small to moderate levels of (Gaussian) noise, the median filter is demonstrably better than Gaussian blur at removing noise whilst preserving edges for a given, fixed window size. However, its performance is not that much better than Gaussian blur for high levels of noise.

Dark-Channel Prior: The dark channel prior (DCP) by He was a novel approach to solving the difficult problem of removing haze from a single image because the model for representing fog or haze is represented by one equation.

Transmission: Transmission is the process of all-optical self-adaptive continuous band-pass spatial filtering system which exploits any nonlinear transmission mechanism. As intensity is increased above threshold, low spatial frequencies are blocked resulting in edge-enhanced images containing high spatial frequencies.

Refined Transmission: Bad weather conditions such as fog, haze and dust often reduce the performance of outdoor cameras; we propose a method based on a dark channel prior for quickly defogging images. It first estimates the intensity of the atmospheric light by searching the sky area in the foggy image. Then it estimates the transmission map by refining a coarse map from a fine map. Finally, it produces a clearer image from the foggy image by using the estimated intensity and the transmission map.

Edge Information: The edge detection methods that have been published mainly differ in the types of smoothing filters that are applied and the way the measures of edge strength are computed. As many edge detection methods rely on the computation of image gradients, they also differ in the types of filters used for computing gradient estimates in the x- and y-directions. The edges obtained from natural images are usually not at all ideal step edges. Instead they are normally affected by one or several of the following effects: focal blur caused by a finite depth-of-field and finite point spread function. Penumbral blur caused by shadows created by light sources of non-zero radius. Shading at a smooth object.

VI. IMPLEMENTATION AND RESULTS

Results of this paper is as shown in bellow Fig.4.

Fig.4.results.

VII. CONCLUSION & FUTURE ENHANCEMENT

In this paper, we propose a novel visibility restoration approach for images captured in varied weather conditions and featuring variable scenes. The proposed approach uses a combination of three major modules: a depth estimation module, a color analysis module, and a visibility restoration module. First, the proposed depth estimation module applies a refined transmission procedure to avoid the generation of block artifacts in the restored image by 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 color analysis 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 visibility restoration module can effectively restore the visibility of input images and obtain high-quality, haze-free results via the depth estimation module and the color analysis module. The experimental results produced by both methods were evaluated by qualitative and quantitative comparisons of images of several realistic scenes with varied weather conditions and features. These analyses illustrate the efficacy of our proposed visibility restoration approach. Not only can it effectively circumvent significant problems regarding color distortion and complex structure, but it can also produce high-quality, haze-free images more effectively than can the method of He et al.

Future Enhancement: To the best of our knowledge, we are the first research group to successfully develop an efficient visibility restoration approach for use in images
captured during varied weather conditions in realistic environments.

VIII. REFERENCES