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Removal Of Fog And Haze In The Digital Images Using Dark Channel Prior Method

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Abstract— Fog and haze degrade the quality of preview and captured image by reducing the contrast and saturation. The objective of the present work is to increase the visibility of an image by remove the fog and haze in the digital image and to enhance the certain features like saturation& contrast of an image. To manipulate the foggy image by enhancing the features like contrast & saturation. Unfortunately, classical approaches have difficulties in adverse weather condition. we propose a simple but powerful prior, dark channel prior, for fog and haze removal from a single input hazy image. By creating linear model on a foggy image, depth information can be recovered. Through the segmentation of the hazy image, we can easily remove the haze from a single image.

Index Terms - Fog removal, haze removal, Dark channel prior, bilateral filter, image enhancement, image segmentation.

1 Introduction

Outdoor scenes are often affected by fog & haze. Often we like to capture such landscapes as fog or haze adds significant visual pull. But , a user may like to capture a clearer picture by reducing the effect of fog especially when the density of fog is too high. In driving scenarios, dense fog reduces the visibility and may cause road accidents. It also affects flight take-offs and landing. Hence, reducing the effect of fog or haze in preview frames and captured images may add significant value in our daily life. In this work we propose an enhanced method of reducing fog or haze from a captured image or from a low resolution camera preview.

Poor visibility due to fog or haze is caused by suspended particles in the atmosphere. The incoming light from a scene or object is scattered due to these particles and hence is attenuated till it reaches the camera. As a result, both saturation and contrast of the captured image reduces significantly. A number of methods are reported in literature for reducing the effect of fog from image by using single or multiple frames[1]-[4]. Sahu[1] proposed a hue preserving method of enhancing foggy image. Tan[2] suggested a method of local contrast enhancement for fog removal. Both the above methods do not use any physical model of degradation and in many cases produce over saturated outputs. Xu, et al. [3] proposed a method on contrast limited adaptive histogram equalization or CLAHE. In this method, the image is converted to HIS color space and the result is converted back to RGB color space. Again, since this method is not based on any physical model, the output is not satisfactory for all images. Munira et al. [4] calculated the transmission map assuming depth of the image as a function of blur. Fattal et al. [5] proposed transmission map based on independent component analysis and showed better enhancement of foggy images. But these methods do not produce good quality output for high fog density.

There are few methods based on multiple images at multiple weather conditions or multiple images with different degree of polarization. For example, Narasimhan et al. [6] used multiple images at different weather conditions to get a fog free image based on atmospheric scattering. However, the method produces inconsistent results since scattering also depends on wavelength of incident light. Zhang Tao et al. [7] proposed a method using multiple images captured at different weather conditions. In their approach, they calculated airlight and transmission map by establishing relation between two images. They removed the fog using physical model by substituting airlight and transmission. The limitation of this method is the availability of same scene or image at different weather.

He et al. [8] proposed dark channel in the

neighbouring pixels window to estimate the airlight and transmission map followed by soft matting to refine the image. The method significantly enhances the quality of hazy images. The main limitations of this method is the computationally expensive matting technique which takes time in the magnitude of tens of seconds for processing an image of resolution 640x480. Also, the method uses a fixed size block for generating transmission map which can't ensure edge preservation and as a result the sharpness of the image degrades. Toka [9] proposed multilevel transmission mapping technique using different block sizes followed by filtering operation.

In the present work, we propose dark channel prior (DCP) method for fog and haze removal followed bilateral filter for better noise removal and edge enhancement. RGB separation process for to discriminate the three colors. An image segmentation process also performed here.

2 METHODOLOGY

A foggy image may be represented as

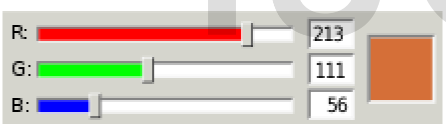
I(x) = J(x)t(x) + A(1-t(x)) ……(1)

Where I is intensity of the pixel, J is original scene radiance, A is the global airlight, and t is medium of transmission describing the portion of light that is not scattered and reaches camera. Airlight A is the result of scattering of light from scene or object. The block diagram of removal fog and haze in the digital images using DCP method is shown in Fig.1.

2.1. RGB Separation

RGB separation operation performed in the digital images for color discrimination. The high quality image is determined by this method. Where R-red, G-green, B-blue in the color image.

Numeric Representations:



Each slider ranges from 0 to 255.

2.2. Compute DCP & Airlight calculation

Dark Channel Prior method is computed by

using expression like

J^{dark} (x) =miny∈Ω(x)(minc∈{r,g,b} J^c (y))..(2)

Where J^c is an intensity for a color channel $c \in \{r, g, b\}$ of the RGB image and $\Omega(x)$ is a local patch centered at pixel x. According to Eq. (2), the minimum value among the three color channels and all pixels in $\Omega(x)$ is chosen as the dark channel J^{dark} (x).

Jdark≈0 …..(3)

This approximation to zero for the pixel value of the dark channel is called the DCP. The value of I at that pixel is considered as airlight for the proposed method.

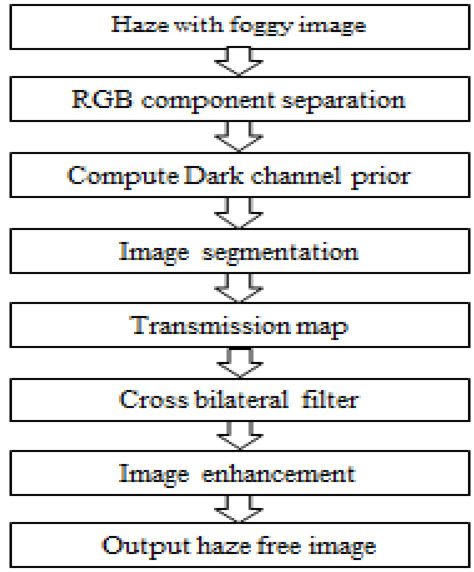


Fig.1. Block diagram

2.3. Image Segmentation

Image segmentation is the image is subdivided into multiple segments and to locate the objects in the corresponding location of image. The goal of segmentation is simplify the representation of image into something that is more meaningful & easier to analyze.

2.4. Transmission map

It is observed that the saturation of color in a foggy image decreases with the density of fog which in turn depends on depth or distance of the object. In the proposed method we combine the saturation and airlight to get a more accurate transmission map is calculated as

t= combine {A (airlight), saturation}

2.5. Cross bilateral filter to merge images

This approach of ours reduces noise and eliminates the need for soft matting thus improving the time required for processing. The cross bilateral filter is second best accuracy. This filter is used to edge preserving and reduce the noise .Intensity values at pixel in an image are replaced by weighted average of intensity values from nearby pixels. Cross bilateral filter does weighted averaging of pixels across multiple frames (radiance image) obtained. The filtering is performed on intensity (Y) of the radiance image. It is defined in [9] as (4)

$$Y^{int}{}_{ij} = \frac{1}{K}\sum_{k=1}^{N}\left\{ e^{\left(\frac{-(Y_{ij}(ref)-Y_{ij}(k))^2}{2\sigma m^2}\right)} Y_{ij}(k)\right\} \quad .....(4)$$

Where Y_{ij} is the filtered output at (i,j) pixel location, N is the number of frames, k1 indicates block size & K is normalizing factor given by, (5)

$$K = \sum_{k=1}^{N} \left\{ e^{\left(\frac{-(Y_{ij}(ref) - Y_{ij}(k))^2}{2\sigma_m^2} \right)} \right\} \quad ....(5)$$

The weight depend on deviation of pixel of current frame from the pixel of reference frame.

2.6. Image enhancement

As discussed earlier, presence of fog or haze in the image reduces the contrast of captured image. Hence, contrast enhancement is performed to restore the contrast. Since the noise component is reduced in the previous step (using temporal filtering) the contrast may be enhanced without enhancing the noise. The contrast enhancement as shown in (6) as

$$I(x,y) = \frac{1}{1 - m^{\gamma} + \left({}^{m}/_{r(x,y)} \right)^{\gamma}} \quad (6)$$

Where m is a threshold, r(x,y) is input intensity and γ is contrast enhancement factor to produce output I(x,y). Based on empirical observation using a number of images we assumed m to be 0.8 times the mean intensity of the image and γ=2.0 in the present work.

3. RESULTS & DISCUSSIONS

3.1. Output image quality

The proposed method of fog removal on a set of images. A few sample images are shown in Fig.4. The output images were enhancement. As the generation of transmission map is based on saturation component, the degradation of the color saturation of image is appropriately compensated at most of the place. The output quality is compared with He et al. [8] in Fig. 5 through measurable parameters, edge visible gradient and edge descriptors as proposed in [12]. It can be seen that the proposed method provides better edge enhancement as compared to the method in [8].

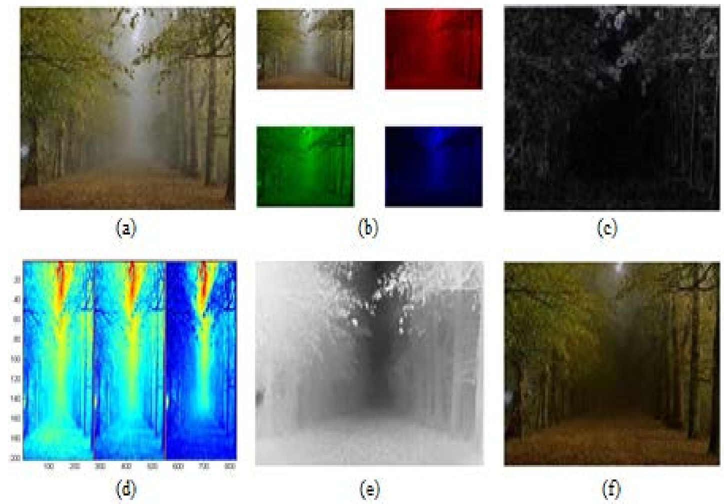


Fig.3. Output results (a) Input hazy image (b) RGB component separation (c) Compute dark channel prior (d) Image segmentation output (e) Transmission map output (f) Final haze free image

3.2. Processing time

Table I shows the performance comparison of the proposed method for desktop processor with respect to the other methods. From the data it is evident that computational complexity of the present method is less as compared to other techniques. The proposed method is optimized further for mobile device (Samsung Galaxy S6, Exynos 7420, Quad-core 1.5 GHz Cortex-A53 & Quad-core 2.1 GH

Fig.4. Comparison of results (a) Input (b) He et al. [8] (c) Proposed method

Tan[2]	Toka[9]	Proposed method
42.857sec	2.142sec	0.104sec

Table I: Performance of the proposed method in mobile device (Samsung galaxy s6, Exynos7420, Quad-core 1.5GHz,Cortex-A53&Quad-core 2.1GHz Cortex-A57)

As the proposed method works faster for smaller resolution we made an attempt to realize it on mobile camera preview in real time so that a foggy scene can have a better visual quality when viewed on camera preview. Another advantage of proposed method is that, it is capable of working with multiple frames of preview or video as we use temporal filtering instead of softmatting. Hence the model is capable of enhancing the preview in the presence of snow or rain as well. During the rain or snowfall the distant object become hazy and rain or snow droplets are visible on relatively closer object of the preview. As the snow and water droplets appear at different positions in the different frames, temporal filtering helps to reduce the visibility of such droplets in the output frame. The haze in higher depth regions is reduced in the same way as we remove fog in the present work.

3.3 Real-time haze removal on mobile camera:

The proposed method is tested on mobile device (Samsung Glaxy S6) for real time proposing of output video streams. The preview is realized to VGA quality to achieve real-time performance(25fps).Since the quality of foggy frames is poor in terms of contrast and saturation ,resizing does not severely degrades the final output quality.

4. CONCLUSION

An enhanced fog and haze removal techniques are proposed by using dark channel prior method. This method is to produce the better quality, saturation & visibility compare to existing method. Our proposed method output has not adding any noise and blocking artifacts in the image. In this method we use the transmission map by using Bilateral filter. Because while using the multilevel transmission map this approach has very difficult and expensive. More time will consume to complete the job. Though the proposed method is faster as compared to existing method, real time fog or haze removal is still challenge for applied in HD cameras. We try to enhance the performance via tri lateral filter. This method is also available in a car navigation. Our future plan is to implement the future in a flight, while passing the infrared rays from the device easy to remove the fog and get clear image from the camera to the pilot. So the flight not get accident in the hilly region even when adverse weather conditions.

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