A Single Image Haze Removal Algorithm Using Color Attenuation Prior

Manjunath.V [*], Revanasiddappa Phatate [**]

[*] Computer Science and Engineering Dept., Veerappa Nisty Engineering college, Shorapur, India
[**] Computer Science and Engineering Dept., Veerappa Nisty Engineering college, Shorapur, India

Abstract- Single image haze removal has been a challengingproblem due to its ill-posed nature. In this paper, we propose a simple but powerful color attenuation prior for haze removal from a single input hazy image. By creating a linear model for modeling the scene depth of the hazy image under this novel prior and learning the parameters of the model with a supervised learning method, the depth information can be well recovered. With the depth map of the hazy image, we can easily estimate the transmission and restore the scene radiance via the atmospheric scattering model, and thus effectively remove the 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.

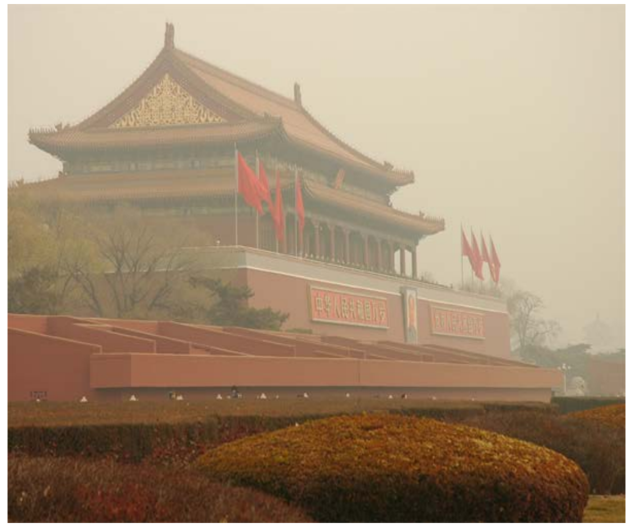
Index Terms- Dehazing, defog, image restoration, depthrestoration.

I. Introduction

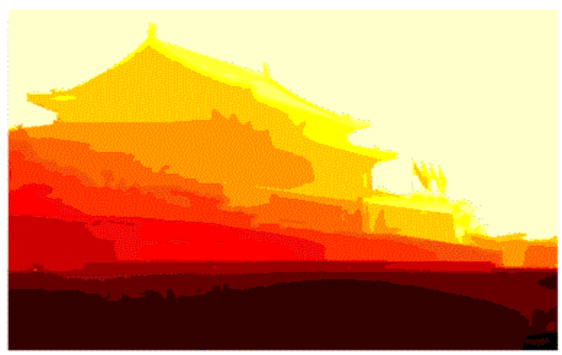
Outdoor images taken in bad weather (e.g., foggy or hazy) usually lose contrast and fidelity, resulting from the fact that light is absorbed and scattered by the turbidmedium such as particles and water droplets in the atmosphere during the process of propagation. Moreover, most automatic systems, which strongly depend on the definition of the input images, fail to work normally caused by the degraded images. Therefore, improving the technique of image haze removal will benefit many image understanding and computer vision applications such as aerial imagery [1], image classification [2]– [5], image/video retrieval [6]– [8], remote sensing [9]–[11] and video analysis and recognition [12]–[14].

Since concentration of the haze is different from place to place and it is hard to detect in a hazy image, image dehazing is thus a challenging task. Early researchers use the traditional techniques of image processing to remove the haze from a single image (for instance, histogram-based dehazing methods [15]–[17]). However, the dehazing effect is limited, because a single hazy image can hardly provide much information. Later, researchers try to improve the dehazing performance with multiple images. In [18]– [20], polarization-based methods are used for dehazing with multiple images which are taken with different degrees of polarization.

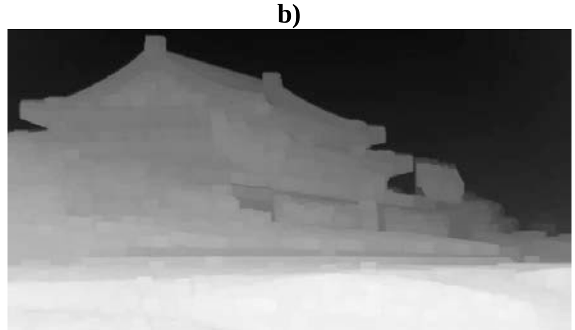
Recently, significant progress has been made in single image dehazing based on the physical model. Under the assumption that the local contrast of the haze-free image is much higher than that in the hazy image.



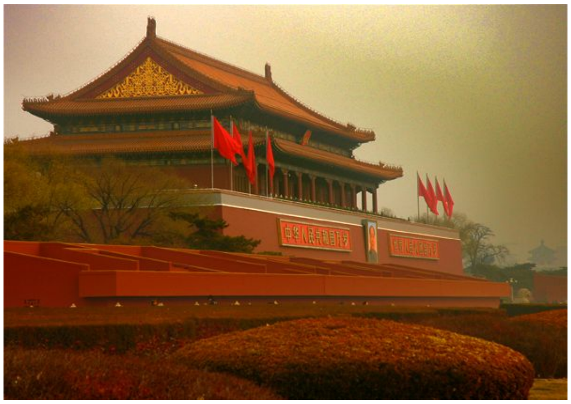
a)



b)



c)



d)

Fig.1 An overview of the proposed dehazing method. a) Input hazy image. b) Restored depth map. c) Restored transmission map. d) Dehazed image.

In this paper, we propose a novel color attenuation prior for single image dehazing. This simple and powerful prior can help to create a linear model for the scene depth of the hazy image. By learning the parameters of the linear model with a supervised learning method, the bridge between the hazy image and its corresponding depth map is built effectively. With the recovered depth information, we can easily remove the haze from a single hazy image. An overview of the proposed dehazing method is shown in Figure 1. The efficiency of this dehazing method is dramatically high and the dehazing effectiveness is also superior to that of prevailing dehazing algorithms.

II. COLOR ATTENUATION PRIOR

To detect or remove the haze from a single image is a challenging task in computer vision, because little information about the scene structure is available. In spite of this, the human brain can quickly identify the hazy area from the natural scenery without any additional information. This inspired us to conduct a large number of experiments on various hazy images to find the statistics and seek a new prior for single image dehazing. Interestingly, we find that the brightness and the saturation of pixels in a hazy image vary sharply along with the change of the haze concentration.

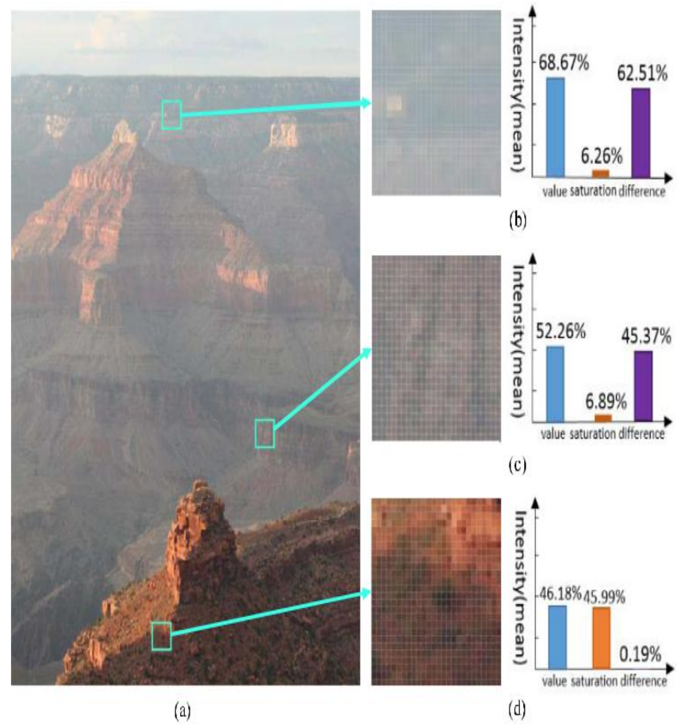


Fig. 2. The concentration of the haze is positively correlated with the difference between the brightness and the saturation. (a) A hazy image. b) The close-up patch of a dense-haze region and its histogram. (c) The close-up patch of a moderately hazy region and its histogram. (d) The close-up patch of a haze-free region and its histogram.

Figure 2 gives an example with a natural scene to show how the brightness and the saturation of pixels vary within a hazy image. As illustrated in Figure 2(d), in a haze-free region, the saturation of the scene is pretty high, the brightness is moderate and the difference between the brightness and the saturation is close to zero. But it is observed from Figure 2(c) that the saturation of the patch decreases sharply while the color of the scene fades under the influence of the haze, and the brightness increases at the same time producing the high value of the difference. Furthermore, Figure 2(b) shows that in a dense-haze region, it is more difficult for us to recognize the inherent color of the scene, and the difference is even higher than that in Figure 2(c). It seems that the three properties (the brightness, the saturation and the difference) are prone to vary regularly in a single hazy image.

III. HAZE REMOVAL ON IMAGE

The block diagram for haze removal of image. Here the input of image is in the form of haze. Then the dehazing applied two different methods. First approach is pre compression; it means the dehazing technique applied after compression. Dehazing techniques are color attenuation prior Then the result applied to compression standards for image in JPEG. The post compression is first input image applied to dehazing techniques before compression. The ringing and blocking artifacts can be reduced by choosing a lower level of compression. They may be eliminated by saving an image using a lossless file format. So, the pre compression is gives better performance and fewer artifacts than the post compression.

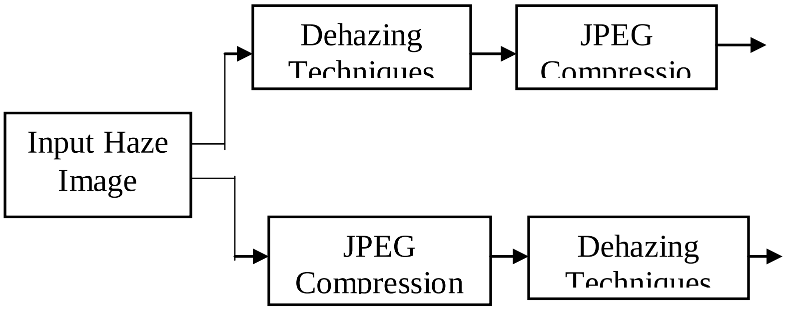


Fig. 3 Block diagram for Haze removal.

IV. SCENE DEPTH RESTORATION

In the Figure 4 illustrates the imaging process. In the haze-free condition, the scene element reflects the energy that is from the illumination source (e.g., direct sunlight, diffuse skylight and light reflected by the ground), and little energy is lost when it reaches the imaging system. The imaging system collects the incoming energy reflected from the scene element and focuses it onto the image plane. Without the influence of the haze, outdoor images are usually with vivid color (see Figure 4(a)). In hazy weather, in contrast, the situation becomes more complex (see Figure 3(b)). There are two mechanisms (the direct attenuation and the airlight) in imaging under hazy weather. On one hand, the direct attenuation caused by the reduction in reflected energy leads to low intensity of the brightness. It reveals the fact that the intensity of the pixels within the image will decrease in a multiplicative manner.

So it turns out that the brightness tends to decrease under the influence of the direct attenuation. On the other hand, the white or gray airlight, which is formed by the scattering of the environmental illumination, enhances the brightness and reduces the saturation. It can be deduced from this term that the effect of the white or gray airlight on the observed values is additive. Thus, caused by the airlight, the brightness is increased while the saturation is decreased.

Since the airlight plays a more important role in most cases, hazy regions in the image are characterized by high brightness and low saturation. This allows us to utilize the difference between the brightness and the saturation to estimate the concentration of the haze.

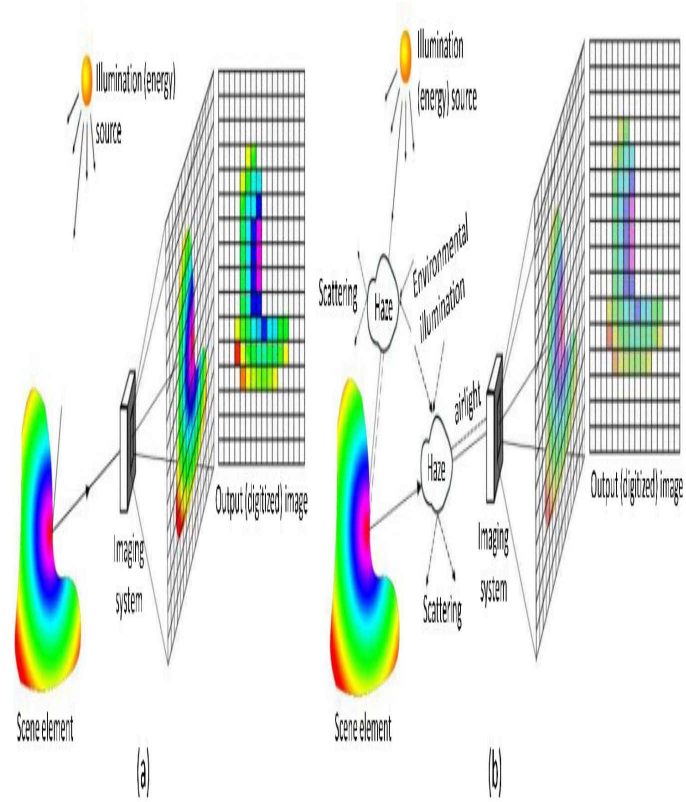


Fig. 4 The process of imaging under different weather conditions. (a) The process of imaging in sunny weather. (b) The process of imaging in hazy weather.

In Figure 5, The difference increases along with the concentration of the haze in a hazy image, Since the concentration of the haze increases along with the change of the scene depth in general, we can make an assumption that the depth of the scene is positively correlated with the concentration of the haze.

a)

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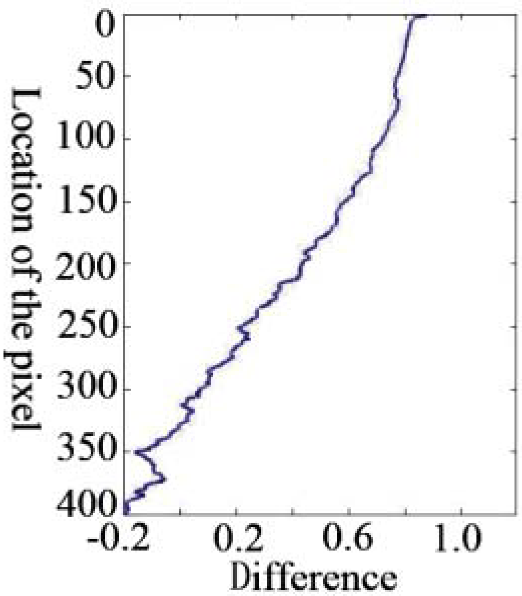
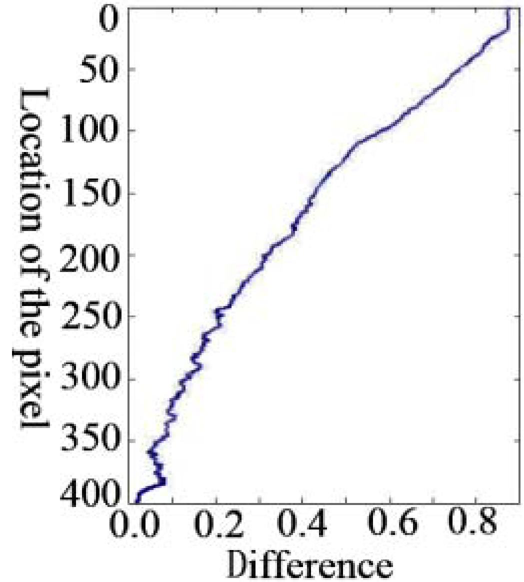
b)



c)



d)

Fig. 5 Difference between brightness and saturation increases along with the concentration of the haze. (a) and (b) A hazy image. (c) and (d) Difference between brightness and saturation.

I. Experimental results

In figure 6, there are different types of Haze images. The input haze images are first applied the dehazing techniques after applying the JPEG compression now we get pre compressed dehaze image and the input haze images are applied the JPEG compression after that applying the dehazing techniques now we get post compressed dehazeimage(output image).

a)

b)

c)

d)

e)

f)

Fig. 6 Difference between the (a), (c) and (e) A hazy image (Input image). (b), (d) and (f) A dehaze image (Output image)

V. CONCLUSION

In this paper, we have proposed a novel linear color attenuation prior, based on the difference between the brightness and the saturation of the pixels within the hazy image. 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 can be well recovered. By means of the depth map obtained by the proposed method, the scene radiance of the hazy image can be recovered easily. Experimental results show that the proposed approach achieves dramatically high efficiency and outstanding dehazing effects as well.

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AUTHORS

First Author – Manjunath.V, Computer Science and Engineering Dept. Veerappa Nisty Engineering college, Shorapur, India, Manjunath060216@gmail.com

Second Author – Revanasiddappa Phatate, Computer Science and Engineering Dept. Veerappa Nisty Engineering college, Shorapur, India, reva.sid09@gmail.com