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Image Dehazing using Dark Channel Prior

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***Abstract*—Windstorms, foggy winters, and sand storms generally degrade image quality and have an impact on computer vision applications, which could be a safety concern for drivers because of light dispersing and retention by dust remnant or air molecules, making the view hazy or foggy. Our method relies on the Dark Channel Prior (DCP) methodology, which improves visual contrast too. Upon quantifying the ambient light, the value is utilized for calculating transmission estimate. The transmission map is fine-tuned afterwards, and even the image is recovered. By processing locally, we simplify the refining stage and localize the refinement zone by working with the coarse dark channel. This strategy will reduce blurriness while restoring the true brilliance of distant objects. To compare we have chosen different existing methods like All-in-One Dehazing Network (AOD-net), Convolutional Neural Network (CNN), High Resolution de-hazer(HR de-hazer) and make the comparison using metrics like Peak Signal to Noise Ratio(PSNR) and Structural Similarity Index (SSIM). Not only in terms of quality parameters but we have also checked over the latency period where we found DCP is giving a valuable output. Hence, the Peak Signal to Noise Ratio value of our proposed method is 20% greater than that of existing methods.**

Keywords*—*Dark channel prior (DCP), Transmission esti- mate map, Ambient light, PSNR, SSIM, Latency,AOD-net, CNN, HR de-hazer.

I. Introduction

Outdoor photos have limited visibility in inclement weather because of assimilation and dissemination by air particles in smog or mist. The substandard visibility affects not only consumer photography, but also has an impact on certain applications for outdoor contexts, namely; identification of object and video monitoring. Haze reduction, also known as a mandatory and important procedure as the pictures without haze are more aesthetically appealing and can in- crease computer vision performance significantly. Dehazing methods provided in previous studies necessitated the use of several pictures. Polarization-based approaches, for example, exploit the polarization feature of light that is deviated to reconstruct scene profound data from more than couple of pictures obtained with various polarization degrees. Likewise, locations are acquired under various weather circumstances in order to serve as denoted images in vivid weather. These approaches with multiple reference pictures, on the other hand, have limitations in online applications that are used to de-fog images and may be required make use of a dedicated imaging sensor[1]. As a result, the research scholars decided to concentrate on only one reference picture to perform the process of removing the haze. Methods depending on a single picture are in tune to the properties of vivid photos without any haze. It improves visibility by enhancing the local divarication

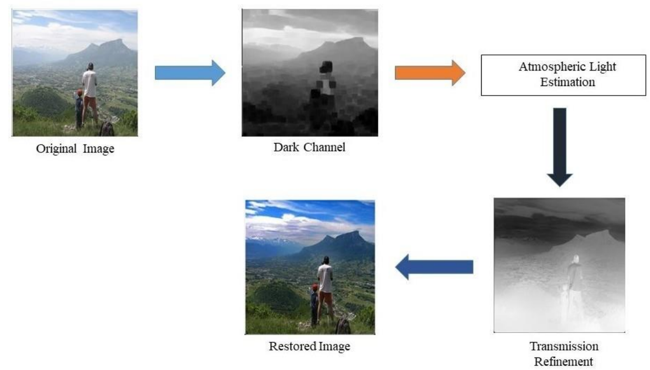

Fig. 1. Flow Chart of the Image Dehazing Process

of the input blurred picture, but it generates blocking artifacts around depth discontinuities. The features of haze-free images are used in methods depending on a single image. It enhances visibility by boosting the input foggy image's local contrast, but it causes blocking artifacts at depth discontinuities. An Estimate of light, estimation of transmission maps, refining of transmission maps, and image reconstruction. In this study, we examine DCP-based approaches from a four-step perspective. There are many papers that gave a review on picture de-blurring. Several techniques are explained and validated for the improvement- and restoration-based defogging strategies are examined. Several techniques are adopted to exploit the pro-fundity and prior knowledge was investigated. A comparison of the four representative dehazing techniques is undertaken. Several methods for improving vision in both binary and ternary fog are presented. The DCP has been adopted by the bulk of modern de-hazing approaches due to its efficacy in de-hazing. Sky region light estimate, transmission map estimation and refinement, and picture recreation are different fundamental processes in DCP-based de-noising approaches. In this study, we examine DCP-based approaches from a four-step perspective as illustrated in following figure 1.

II. Dark Channel Prior

On Dusk-free outdoor photos, The DCP is based on the fact that in most non-sky locations, at least one-color tone has very low contrast at some pixels. To put it another way, the patch's minimum intensity should be quite low. Formally, we define an image J as [3]

$$J^d(x) = min(min(J^a(y))), a \in \{r, g, b\} \qquad (1)$$

Fig. 2. Input Noisy Picture and Picture After finding Dark Channels

Where J^a is a medium of $J(x)$ which is a local patch with x as its center. Except for the sky region, [4] the contrast of $J^d(x)$ is minimum and goes to naught if J is an outdoor photo without haze, according to our observations. $J^d(x)$ is J's dark channel, and the DCP is above quantitative inspection or knowledge. When the pixels in the atmospheric region are deleted from the dark channels of outdoor fogless photos, around 79 % of the pixels have values equivalent to 0 and 89 % of the pixels have values are lower than 35. [5] The low intensities in the dark channel are due to the following three basic features [6]: a) shadows, b) colorful objects or surfaces. c) Items or surfaces that are black in appearance. The element of image value in the low intensity channel can be estimated as stated below based on the aforementioned [7] observation:

$$J^d \approx 0 \tag{2}$$

The low contrast pixel value is estimated to zero using the DCP. Dark channels from blurry photos, on the other hand, yield pixels with values well above zero. The tri-color channels with the least quantity of pixels in the local patch is greatly increased by a combination of air light and direct attenuation, as worldwide ambient light behaves to be self-colored and illuminated. As a result, the dark channel's pixel values can be used as a key indicator for estimating haze density. The efficiency of the DCP in image de-fogging is supported by the successful defogging outcomes of several DCP-based de-hazing algorithms.

III. DCP BASED IMAGE DEFOGGING

The darker channel is formed from the input picture in the DCP-based defogging process and is then used to build the ambient air light and propagation map. [8] The same is fine-tuned, and the end result is a dusk-free image.

$$I(x) = J(x)t(x) + A(1 - t(x)) \tag{3}$$

Eq. (6) is divided by A^a on both sides, the lowest intensity in each RGB channel's local window is calculated as follows:

$$min_{y\in \upsilon(x)}(I^a(y))/(A^a) = t(x)min_{y\in \upsilon(x)}(J^a(x))/(A^a) + (1 - t(x)) \tag{4}$$

The transmission in the local patch (x) is considered to be consistent and is denoted by the symbol t (x) [9].

The RGB color channels' min operator can then be applied to Eq. (7) as follows:

$$min_{y\in \upsilon(x)}(min_a(I^a(y))/(A^a)) = t(x)min_{y\in \upsilon(x)}(min_a(J^a(y))/(A^a)) + (1 - t(x)) \tag{5}$$

Following with the dark channel prior approximation of Eq. (5), t (x) can be illustrated as

$$t(x) = 1 - min_{(y\in \upsilon(x))}(min_a(I^a(y))/(A^a)) \tag{6}$$

To create the transmission map t, the ambient light A must be estimated. Past single-image dehazing methods determine A from the pixels having the most haze. As described in DCP, the dark channel pixel values are closely connected with haze and density. As a result, the top one-tenth percent of the dark channel's brightest pixels are picked first, the value for A [10] is the hue with the greatest contrast quantity among the chosen pixels.

If the pixels in the regions are picked to predict A instead of the pixels with the highest intensity value, substantial estimation errors arise. The DCP is unreliable because by identifying candidate pixels in the dark channel, the pixel that correctly predicts A in the sky area may be identified. Fortunately, in hazy images, the sky colour is near to A, so we have

$$min(min(I^a/A^a)) \approx 1 \text{ and } t(x) \approx 0 \tag{7}$$

As $d(x)$ tends to infinity, the atmospheric area correlates to the value of $t(x)$. For calculating the transmission map estimate, the sky does not require any additional calculation if we acquire $t(x)$ from Eq. (9). From the observed values of A, t, and I, the de-fogged image is given by the equation.

$$J(x) = (I(x) - A)/max(t(x), t_0) + A \tag{8}$$

Here t_0 is utilized as a minimum boundary of the transmission map.

IV. ESTIMATION OF ATMOSPHERIC LIGHT

The most of de-hazing algorithms are dependent upon DCPs appropriate value of A. The pixels having highest dark channel in [14,16] the following is an example of how value is utilized directly:

$$A = I(argmax_x(I^d(x))) \tag{9}$$

When the image contains bright objects, however, the above approach does not correctly choose the pixels. Instead, the mass haze-opaque pixels are chosen from the top (p) percent of the dark channel values, and the pixel with the maximum intensity is chosen for estimating A. In the estimation of A, there is still one parameter p, which is empirically set to 0.1.

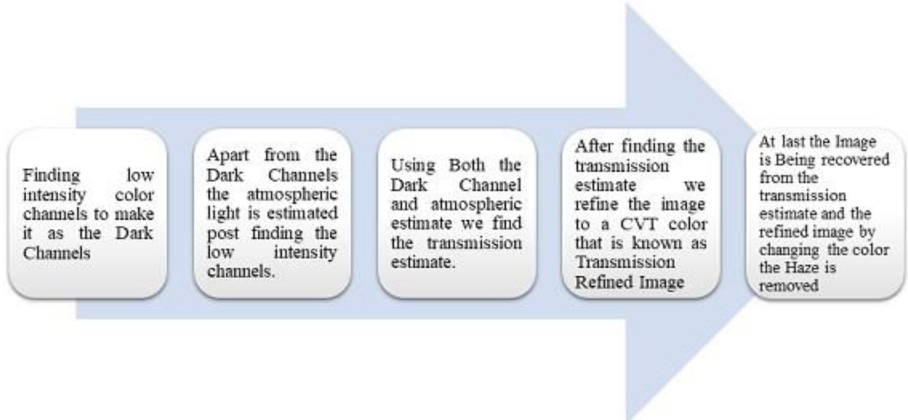

Fig. 3. Flow Chart of Image De-hazing Algorithm

V. Transmission Map Estimate

The Transmission map t(x) defined in eq (8). Was found from the DCP. If it is not explored then an equation can be illustrated as

$$t(x) = 1 - min_{y\in \upsilon(x)}(min_a(I^a(y))/(A^a)) + t(x) min_{y\in\upsilon(x)} (min_a(J^a(y))/(A^a)) \quad (10)$$

The pixel entity of the channel, $J^d(x)$, is highly likely to be zero, and also $(J/A)^d(x)$. If $(J/A)^d(x)$, is not near to zero [15], the transmission map derived using Eq. (9) may be underestimated since affirmative offset is ignored.

$$t(x) = 1 - min_{y\in \upsilon(x)}(min_a(I^a(y))/(A^a)) \quad (11)$$

The image may appear odd in the DCP based defogging method, thus we utilize a constant to keep small amounts from the eq (11). As a result, the enhanced visibility of the dusk-free image may be noticed using eq (11) as we recoup for underestimating of t by multiplying with (x).

VI. Image Refinement

Misleading textures and blocking artifacts may occur from an erroneous transmission map estimate. The block-min approach in Eq. (4), in particular, reduces the observed resolution of the dark channel, yielding hazy transmission maps. As a result, numerous approaches for sharpening the transmission map have been devised [10, 11, 12, 13, 14, 16]. Points out that several de-noising algorithms differ in their approach to smoothing the transmission map. To increase the transmission map's accuracy. Some filtering techniques, like Gaussian and bilateral filters, rely solely on transmission maps, but others, such as soft matting, cross-bilateral filtering, and guided filter- ing, make use of a fuzzy color picture as a guidance signal. In our case we used Guided Filter to enhance the image without losing the clarity over image.

Fig. 4. (a, b) input hazy images, (c, d) output recovered images by DCP algorithm

VII. Experimental results

Dark channel prior approach algorithm. We used Python to transform the mathematical equations into different lines of code. To evaluate the code's strength, we took some images as input data and focused on a single image dehazing, which resulted in the outputs shown in the figure(4) and figure(5). We examined several methodologies with our proposed method using three metrics to measure picture qualities and processing speed: 1. PSNR (Peak Signal to Noise Ratio)

Latency and 3. SSIM (Structural Similarity Index Measure).

To differentiate our suggested method to other current techniques such as dehazing using CNN, AOD-Net, and HR Dehazer, we conducted a statical study using the metrics indicated in the image (6,7,8). If the PSNR number is high, the image quality is said to be good. Except for HR-Dehazer, which offers high PSNR values but requires longer time, which is well expressed in latency values, our proposed method

Fig. 5. (a,b,c) input hazed images and (d,e,f) output refined images

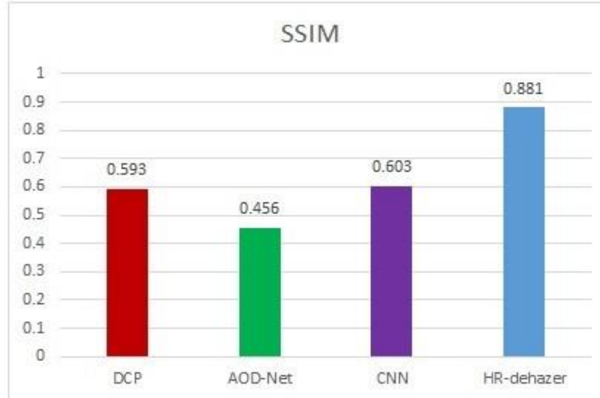

Fig. 7. Comparing SSIM values of different Methods

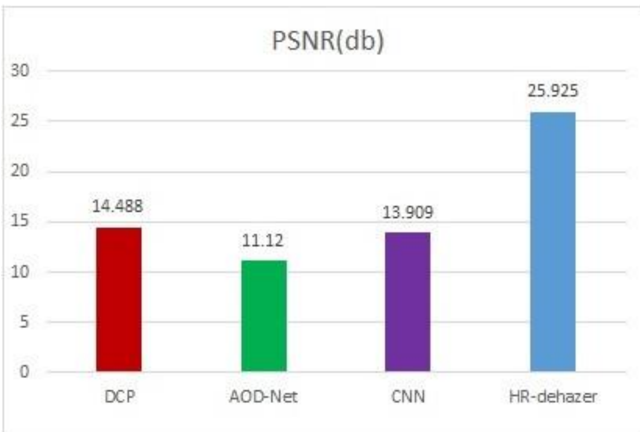

Fig. 6. Comparing PSNR values of different Methods

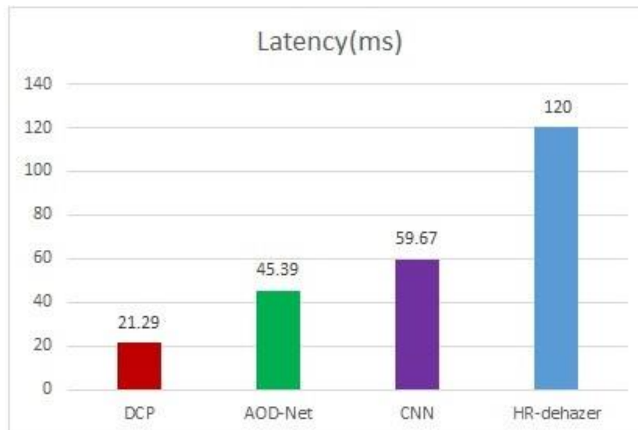

Fig. 8. Comparing Latency values of different methods

has given significantly more PSNR among other methods. DCP is faster than other methods in terms of processing speeds because it produces a suitable output. At last we have also checked the Structural Similarity Index of the recovered images, which showed that DCP is giving a better image quality.

TABLE I COMPARISON OF QUALITY METRICS

Methods	PSNR(db)	SSIM	Latency(ms)
DCP method	14.488	0.593	21.29
AOD-net	11.120	0.456	45.39
CNN	13.909	0.603	59.67
HR-Dehazer	25.925	0.881	120

VIII. CONCLUSION AND FUTURE SCOPE

A. Conclusion

We investigated the Dark Channel Prior based picture defogging method, which is an effective defogging algorithm.

Using the major phases of the suggested approach for removing fog from photos, we obtain the approximate value of ambient light and the estimated value of transmission. Using these two values, we refine and reset the image by removing the noise. The most recent DCP-related research articles have been categorized and a steep wise analysis of traditional approaches has been undertaken. It can be believed that our exhaustive research and practical analysis would enable readers get an understanding about DCP-based defogging methods as a result of which the advanced defogging algorithms can be facilitated.

The single image defogging has been successfully com- pleted with DCP and then OpenCV is used in the Python library so that is applied to the actual footage. We have successfully executed for real-time situation; and hence, the technique has the ability to be merged with hardware such as imaging sensors and validate it on real-time platforms.

B. Future Scope

We observed in this project that a degraded image or video quality can be enhanced using a variety of approaches, but that DCP is our method of choice. However, although any project might have a scope of development, we can observe our future developments in our proposed technique by growing the scale of the project by implementing in real-time cars. This can be brought to market at a low cost to allow people to drive safely by embedding some imaging sensors with a navigational interface that allows them to watch traffic even in foggy or hazy circumstances.

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