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Hybrid Dehazing Technique using IDCP with Histogram Equalization for Color Image

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ABSTRACT
Haze formation is the blend of air-light and attenuation. Attenuation reduces the contrast and air-light enlarges the whiteness in the captured image. Fog and haze are atmospheric conditions generated by floating particles, degrade the quality of images. Haze removal algorithms have become more beneficial for several vision applications. As we know there is no single technique i.e. accurate for all different kind of problems and circumstances. The existing approaches have neglected many issues like noise reduction and non-uniform illumination which will be presented in the output image of the existing haze removal algorithms. This dissertation has proposed a new haze removal technique HDCP which will integrate improved dark channel prior with histogram equalization to remove the haze from color images and weighted guided filter is used to decrease noise from images. The proposed algorithm is implemented and tested in MATLAB. The results have shown that the proposed algorithm has shown quite effective results.

Keywords
Attenuation, Air-light, Weighted guided filter, Bilateral filter, Histogram Equalization.

1. INTRODUCTION
Computer vision systems are used in many outdoor applications like video surveillance, remote sensing. So, mostly task under computer vision assumes that input image is taken in clear weather i.e. always not true. Mostly time the images captured in bad weather are of poor quality. So, the main objective of image processing is to understand, recognize and interpret the data from the image pattern. In few cases pictures might be defiled by moisture less particles for example: dust, smoke, snow, haze and fog. These poor climate conditions degrade the clearness of the pictures. While expanding the distance or separation among object and the camera clarity of the pictures naturally decreases. Haze and fog are an atmospheric effect but they are different with each other as: fog is thick and opaque effect while haze is thin and translucent effect. Haze removal is highly required in computer vision and computer graphics applications. Removing the haze from the input hazy image can essentially enhance the perceivability of the images. The haze free image is fundamentally visually satisfying in nature. Many vision algorithms suffer from low-contrast scene radiance. In Computer Vision area dehazing is one of the challenging tasks as because the haze is dependent on unknown depth. For a single input hazy image the haze removal problem or task is under constrained problem. Haze is an atmospheric phenomenon where dust, smoke and other dry particles diminishes the clearness of the sky. The method of removing haze from images is called dehazing. Haze is an atmospheric phenomenon i.e. combination of attenuation and air-light, which causes degradation of outdoor images and weakening both color and contrast of images. The poor weather conditions may diminish the quality of the images of outdoor location. Imaging process during sunlight and hazy weather is shown in fig. 1 and fig. 2 respectively [1].

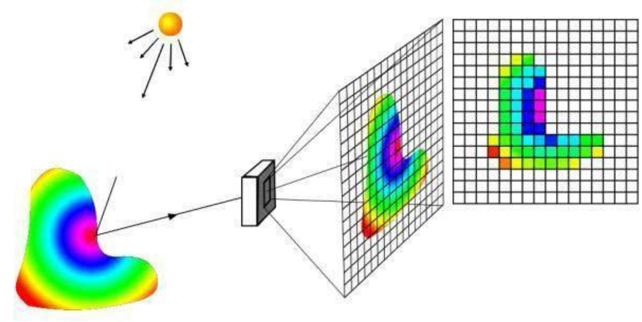

Fig. 1 Imaging process During Sunlight

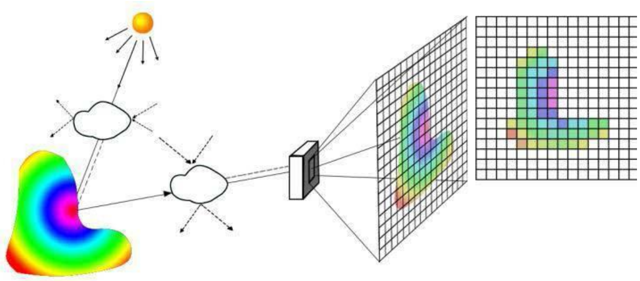

Fig. 2 Imaging During Hazy Weather

These atmospheric conditions are used to blur the captured images. The air is added some misted particles and these particles are scattered around the reflected light which is also scattered. These scattered functions mainly classified into two types, which are attenuation and air light.

1.1 Attenuation
The light beam coming from a scene point gets attenuated because of scattering by atmospheric particles called attenuation which decreases the contrast of the scene.

1.2 Air-light
The light coming from a source is scattered toward camera and give on to the shift in color it is called air-light. The fog effect is the function of the distance between the scene point and viewer or camera. Hence removal of fog needs the estimation of air-light map. From the atmospheric point of view weather conditions differ mainly in the types and sizes of the particles present in the space [2].

1.3 Weighted guided filter

The smoothing process generally decomposes an image to be filtered into two layers: a base layer formed by homogeneous regions with sharp edges and a detail layer which could be either noise. Local filtering based edge preserving smoothing techniques suffer from halo effects. A weighted guided image filter (WGIF) is introduced by incorporating an edge aware weighting into an existing guided image filter (GIF) to address the problem [3].

1.4 Bilateral filter

A bilateral filter is a non-linear, edge-preserving and noise-reducing smoothing filter for images. It replaces the intensity of each pixel with a weighted average of intensity values from nearby pixel. This weight can be based on a Gaussian distribution. Crucially the weights depend not only on Euclidean distance of pixels but also on the radiometric differences (e.g. range differences such as color intensity, depth distance etc). This preserves sharp edges.

1.5 Soft matting

Soft Matting is the problem of accurate foreground estimation in images and videos has significant practical importance. It is a key technology in image editing and film production and effective natural image matting techniques can greatly improve current professional workflows. It necessitates techniques that handle real world images in unconstrained scenes.

Unfortunately current soft matting approaches do not generalize well to typical everyday scenes. This is partially due to the difficulty of the problem:- as formulated the matting problem is under constrained with 7 unknown values per pixel but, only 3 known values:

$$\mathbf{I_i=\alpha_i F_i+(1-\alpha_i)B_i \quad \alpha_i \in [0,1]} \tag{1}$$

Where, the RGB color at pixel i, I_i, is known and the foreground color F_i, background color B_i and matte estimation α_i are unknown. However, current methods are further limited in their approach.

1.6 Histogram Equalization

Histogram equalization is a technique or method to adjust an image intensity to enhance contrast. This method generally increases the global contrast of several images especially when the usable data of the image is represented by close contrast values. Through this adjustment the intensities can be much better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this task by effectively spreading out the most frequent intensity values [4].

This paper is organized into 7 sections. In the next section, literature review has been discussed. In section 3 proposed methodology is explained in detail. In (section 4, 5, 6 and 7) result, conclusion, its future scope and references have been given respectively.

2. LITERATURE REVIEW

Zheqi Lin et al. [5] proposed a new fast dehazing method to remove haze from real time image and video processing. The transmission map estimated by an improved guided filtering scheme is smooth and respect with depth information of the underlying image. Results demonstrate that this proposed method has achieved good dehazing effect as well as real time performance.

Xiaoyan Yuan et al. [6] proposed a single image dehazing method. Aim was to address the inherent limitations of the extensively employed dark channel prior (DCP). More concretely they introduced the Gaussian mixture model (GMM) to segment the input hazy image into scenes based on the haze density feature map. With the segmentation results combined with the proposed sky region detection method through this, they can effectively recognize the sky region where the DCP cannot well handle this. On the basis of sky region detection they then presented an improved global atmospheric light estimation method to increase the estimation accuracy of the atmospheric light. Further they presented a multi-scale fusion based strategy to obtain the transmission map based on DCP which can significantly reduce the blocking artifacts of the transmission map. To further rectify the error-prone transmission within the sky region. An adaptive sky region transmission correction method is also presented. Finally due to the segmentation-blindness of GMM they adopted the guided total variation (GTV) to handle this problem while eliminating the extensive texture details contained in the transmission map. Experimental results verify the power of their method and show its superiority over several state-of-the-art methods.

Nidhi V. Kothari et al. [7] has given the review of image enhancement and restoration methods to improve the quality and visibility level of an image to provide a clear, fog-free image even in poor weather condition. The review work includes the classification of various approaches or methods that could be selected to introduce enhancement and restoration of images. It could then serve as the base to start with new research work by upcoming researchers.

Shuai Yang et al. [8] have introduced an improved single image haze removal algorithm, which combines dark channel prior (DCP) and histogram specification. First, the dark channel prior knowledge proposed by Kaiming. He analysed and gave a conclusion is that the haze removal image based on dark channel prior will have a tendency to dim and indistinct in some specific situations. Especially, when cleaning the haze in the image with large background area and low contrast, DCP result appears obvious anamorphous. Next, in order to improve the dehazing result of this kind of image, they proposed an approach to change the contrast and intensity of haze removal image after DCP method by rebuilding the histogram of the image. Then, a modified approach is applied to fit general haze image. They experimented their method with a variety of outdoor haze images.

Yadwinder Singh et al [9] have proposed a new haze removal technique HDCP which integrates dark channel prior with CLAHE to remove the haze from color images and bilateral filter is used to reduce noise from images. The proposed algorithm is designed and implemented in MATLAB.

3. PROPOSED METHODOLOGY

The concept of defogging algorithms for images originate from an atmospheric scattering model was proposed by Koschmieder [10]. According to Koschmieder's law [11,12], the effect of fog or haze is represented as:

$$\mathbf{I(i,j)=I_{attenuate}(i,j)+A_{ir\text{-}light}(i,j)} \tag{2}$$

In the above equation, two right-hand side terms, attenuation and air-light are the functions of distance from camera to the scene represented as:

$$\mathbf{I_{attenuate}(i,j)=I_0(i,j)e^{-\beta d(i,j)}} \tag{3}$$

$$A_{ir\text{-}light}(i,j)=I_{\infty}(1-e^{-\beta d(i,j)}) \quad (4)$$

where, $I_{attenuate}(i,j)$ is the attenuated image intensity at pixel (i,j) in poor weather, mostly hazy and foggy in nature and $I_0(i,j)$ is the image intensity of the de-weathered image. β is the extinction or atmospheric scattering coefficient based on the wavelength of light function, which is related to the fog concentration and reflects the optical absorption of aerosol in the air and determines the atmospheric visibility. d(i,j) is the distance of the scene point from a camera and I_{∞} is the global atmospheric constant or sky intensity.

More simply fog model can be represented [13, 14] as:

$$I(z)=I_0(z)t(z)+A(1-t(z)) \quad (5)$$

where, I(z) is observed a foggy image, $I_0(z)$ is scene radiance or reflectance (fog-free image as desired), A is the global atmospheric light or skylight and t(z) represents the transmission parameter, the portion of light which directly goes towards observer without scattering in the medium.

The fog-free image is restored as follows:

$$I_0(z) = \frac{I(z)-A}{t(z)} + A \quad (6)$$

This model is also applicable to a color image by applying this on each RGB component. After getting a poor contrast-restored image, histogram equalization is applied to get enhanced haze free image.

In this section, the proposed method is described in detail. The transmission and the air-light are estimated firstly, then the transmission is smoothed and up-sampled using a weighted guided filter, and finally the haze-free image is restored and the core of this proposed method is that it is that after getting haze free image, histogram equalization is applied to enhance the result. Proposed method can be represented diagrammatically as shown below in fig 3.

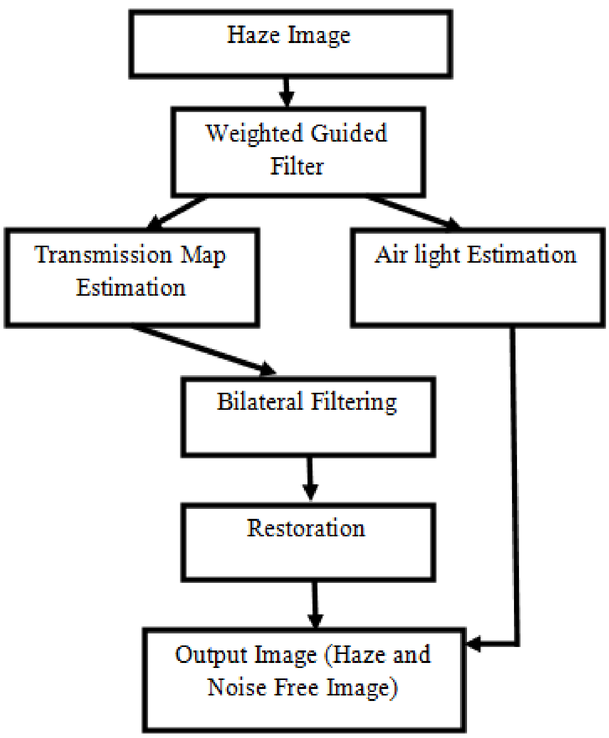

Fig 3: Block Diagram of Proposed Method

Input image: Haze image that also contains noise.

Output Image: Haze and noise free image.

Steps followed in proposed method are:

Step-1: Filter out noise from the input image using weighted guided filter.

Step-2: Firstly, the dark channel of the hazy image is calculated.

Secondly, the transmission map is calculated using the equation

$$t = 1 - w * \frac{D}{A} \quad (7)$$

Where t is transmission map, w is the weighted map, D is dark channel original, A light is the atmospheric.

After this refinement of transmission map is done.

After refinement, Haze free image is restored using below equation:

$$I_0(z) = \frac{I(z)-A}{t(z)} + A \quad (8)$$

Step-3: Once the dark channel prior is applied to the image then histogram equalization is applied to each color channel of the color image independently and finally resultant image is noise and haze free.

4. RESULT & DISCUSSION

Simulation and performance evaluation of the proposed algorithm is accomplished through various foggy images processed on MATLAB platform. The proposed method is compared with DCP and from experimental results it is clear that proposed method gives better results.

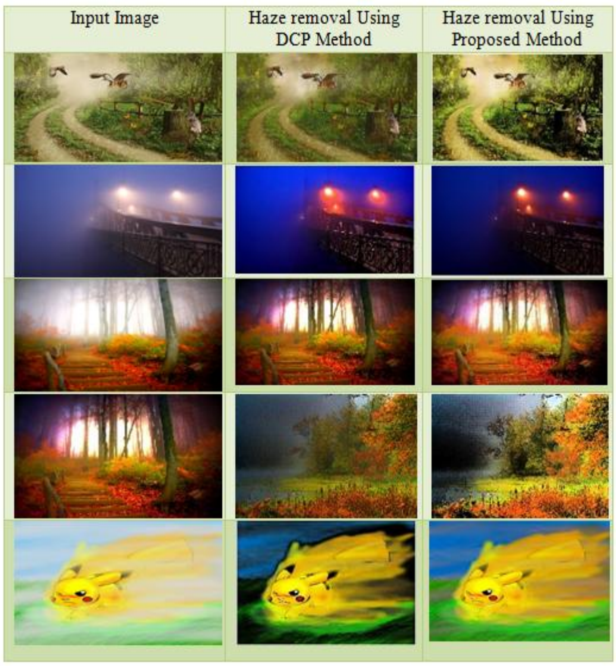

Fig 1: Result using DCP and Proposed Method

Contrast gain: Contrast gain is referred as the mean contrast difference between fog free output and input foggy image. The higher the value of contrast gain (CG), the better is the performance of the algorithm as it is known that fog-free images have more contrast in comparison to the fog affected images. If the mean contrast of the defogged output and the foggy input image of size M×N are represented by $C_{I,def}$ and $C_{I,fog}$ respectively then *CG* is defined as:

$$\mathbf{CG} = \mathbf{C_{I,def}} - \mathbf{C_{I,fog}} \quad \textbf{(9)}$$

And the mean contrast of an image is expressed as:

$$CI = \frac{1}{MN}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1} C(i,j) \quad \textbf{(10)}$$

Where C(i,j) is the contrast of the pixel at location (i,j) and is defined as:

$$C(i,j) = \frac{s(i,j)}{m(i,j)} \quad \textbf{(11)}$$

Where m(i, j) and s(i, j) are behaving like a mean and variance respectively of an image I(i, j) as follows:

$$m(i,j) = \frac{1}{(2p+1)^2}\sum_{k=-p}^{p}\sum_{l=-p}^{p} I(i+k, j+l) \quad \textbf{(12)}$$

and,

$$s(i,j) = \frac{1}{(2p+1)^2}\sum_{k=-p}^{p}\sum_{l=-p}^{p} |I(i+k, j+l) - m(i,j)| \quad \textbf{(13)}$$

For simulation purpose, p=1 (3x3 window) is used in this paper to calculate *CG (Contrast Gain).*

In this paper another measure i.e. CIE (Color information Entropy) is used. Entropy is referred as a statistical measure of randomness that can be used to characterize the texture of the input image. It can be determined from the histogram of an image of all gray levels. However, the image may be two dimensional or multidimensional. The CIE represents the amount of information in a color image. CIE contains its maximum value when an image is non-uniform but for a foggy or haze containing areas in an image has minimal CIE. CIE is mathematically defined as:

$$CIE = -\sum_{k=0}^{L-1} P_k \log_2 (P_k) \quad \textbf{(14)}$$

Where, L is the number of gray levels and P_k is the probability associated with gray level k. CIE should be greater for the desired result.

The proposed method is tested on 10 images and their corresponding average color information entropy and average contrast gain is shown below in Table 1.

Table 1: Comparison of Proposed method with DCP

Method Name	No. of Images (Tested)	Color Information Entropy	Contrast Gain
DCP	10	7.22428	.2000
Proposed	10	7.63246	.2110

5. CONCLUSION

Fog removal is one of the basic and important tasks in computer vision while developing a robust and versatile system. There are two kind of fog removal technique: single image based and multiple image based fog removal techniques. We have focused on single image fog removal using IDCP (Improved Dark Channel Prior) and histogram equalization. Single image fog removal is important step for the systems like object tacking, traffic sign recognition etc. The proposed technique gives pleasant output. Experimental results and analysis shows that haze free image contains more clear edges with better contrast. Fog removal algorithms are easy to implement for a single image, but for video, it can be extended using motion estimation.

6. FUTURE SCOPE

This technique can be extended with other filters to use for different kind of images and videos and also to enhance the result.

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8. REFERENCES

[1] Angitha P V and Santhini K A, “A Review on Image Dehazing Techniques,” International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE), vol. 5, pp. 7498-7506, April 2017.

[2] Kaiming He, Jian Sun, and Xiaoou Tang, Fellow, IEEE, Single Image Haze Removal using Dark Channel Prior, IEEE, December 2011.

[3] H.Geethu, S.Shamna, Jubilant J.Kizhakkethottam Dr., " Weighted Guided Image Filtering and Haze Removal in Single Image" Procedia Technology, ELSEVIER Volume 24, 2016, Pages 1475-1482.

[4] Histogram equalization https://en.wikipedia.org/wiki/Histogram_equalization

[5] Zheqi Lin, Xuansheng Wang, “Dehazing for Image and Video Using Guided Filter”, Open Journal of Applied Sciences, pp. 123-127.

[6] Xiaoyan Yuan, Mingye Ju, Zhenfei Gu and Shuwang Wang, “An Effective and Robust Single Image Dehazing Method Using the Dark Channel Prior”, MDPI, pp. 1-19, May 2017.

[7] Nidhi V. Kothari, Khushali R. Raval, “A Qualitative Classification of Various Enhancement Restoration and Filtering Techniques for Dense Fog Removal from Images”, International Journal for Scientific Research & Development (IJSRD), Vol. 2, pp. 383-388, 2015.

[8] Shuai Yang, Qingsong Zhu, Jianjun Wang, Di Wu and Yaoqin Xie, “An Improved Single Image Haze Removal Algorithm Based on Dark Channel Prior and Histogram Specification” SPRINGER, pp. 279-292, 2013.

[9] Yadwinder Singh, Er. Rajan Goyal, “Haze Removal in Color Images Using Hybrid Dark Channel Prior and Bilateral Filter”, International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC), volume: 2 issue: 12, pp. 4165-4171, December 2014.

[10] W.K. Middleton, Vision through the Atmosphere (1957)

[11] Y.Y. Schechner, et al., Instant dehazing of images using polarization, Computer Vision and Pattern Recognition, in: Proc. IEEE Computer Society Conference, 1(2001), pp. 1–325.

[12] J.P. Tarel, N. Hautiere, Fast visibility restoration from a single color or gray level image, in: Proc. 12th IEEE International Conference on Computer Vision, pp. 2201–2208 (2009).

[13] K. He, et al.Single image haze removal using dark channel prior IEEE Trans. Pattern Anal. Mach. Intell., 33 (12) (2011), p. 2341

[14] Lee, et al. A Review on dark channel prior based mage dehazing algorithms EURASIP J. Image Video Process., 1 (2016), pp. 1-23

[15] Md. Imtiyaz Anwar, Arun Khosla," Vision enhancement through single image fog removal" Engineering Science and Technology, an International Journal, Volume 20, Issue 3, June 2017, Pages 1075-1083.

[16] K. He, et al. Single image haze removal using dark channel prior IEEE Trans. Pattern Anal. Mach. Intell., 33 (12) (2011), p. 2341