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Haze Removal on Image Using Dark Channel and Bright Channel Methods

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Abstract**—**Haze is a main degradation of outdoor images, weakening both colors and contrasts due to atmospheric phenomena. Dehazed images mean sustaining low bitrates in the transmission pipeline. .In this paper to remove haze from a single input image combination of dark channel and bright channel method were used. In a dark channel method , the non-sky patches, at least one color channel has very low intensity at some pixels or, the minimum intensity in such a patch should has a very low value. A kind of statistics of outdoor haze-free images is a dark channel prior method. Then estimate the bright channel to control the amount of brightness enhancement and combine both dark channel and bright channel method to remove haze. The Noise estimation can be measured using MSE (Mean Square Error), RMSE (Root Mean Square Error), BER (Bit Error Rate), PSNR (Peak Signal-to-Noise Ratio) and MAE (Median Angular Error). Experimental result shows that the proposed method can provide the better restored result than the existing methods.

Keywords**—** Image Dehazing, Dark Channel prior, Contrast Enhancement.

I. INTRODUCTION

Images of outdoor scenes are usually degraded by the turbid medium (*e.g*., particles, water droplets) in the atmosphere. Haze, fog, and smoke are such major phenomena that occur due to atmospheric absorption and scattering. The irradiance is received by the camera from the scene point and is attenuated along the line of sight. Furthermore the airlight is blended with the incoming light (ambient light is reflected into the line of sight by atmospheric particles). The Images that are degraded lose the contrast and fidelity of the color. The amount of scattering depends on the distances of the scene points from the camera and hence, the degradation is spatial-variant. Fog tends to get formed when water is suspended in the air just like cloud but at ground level. With increase in pollution, the thickness of fog increases because the particles in air allow more water droplets to get condensed. There are different kinds of fogs occurring in nature. It disappears when the sun rises. It is caused by cooling of land overnight and the thermal radiation then cooling the air close to the surface. Condensation of water content occurs when air is no longer able to hold its moisture. Freezing fog occurs when water droplets remain in liquid state even in spite of temperature falling below freezing point. The condition of valley fog may go on for days. The concept behind valley fog is that when dense, cold air settles at the bottom of a valley and hotter air passes above the valley. Evaporation fog is a local phenomenon which leads to formation of frost. It happens when cold air passes over warm water and moist land. This resultsinformation ofmist. This is a common sight around hot tubs[1]. Advection fog is habitually seen around coastal areas. This causes when air with high moisture content passes over a cool surface.

(i) Light reflected from the surface of item can be attenuated caused by simply dust.
(ii) Some of light flux is definitely spread towards a camera

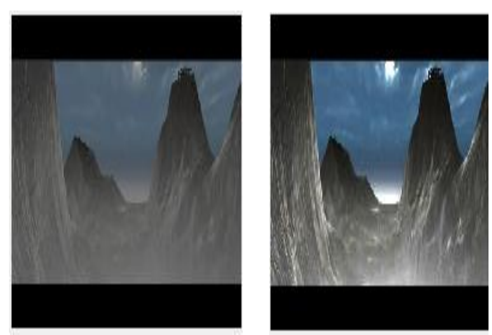

Fig 1(a) Fig 2(b)
Result of image (a) with fog/haze and (b) without fog /Haze

II. LITERATURE SURVEY

R. T. Tan [8] proposed haze renovation technique using single image. This technique requires a 3D model of the scene and textures of the scene (from satellite or aerial photos). This technique depends on user interaction and for alignment it require 3D model with the scene. Formation of image and considerable amount of special information extracted from additional images.

S. G. Narasimhan and S. K. Nayar [4] proposed haze renovation technique using multiple images. They assumed 2+ bad weather images which uses geometric constraints to estimate the de-haze image. The air light component [1-t(x)] is estimated from corresponding pixels of the two bad weather images [7]. This system requires special equipment (polarizes) or same scene under different weather conditions. A result of this approach is not that much better than single-images approaches.

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Fattal [10] proposes an approach based on Independent Component Analysis (ICA). Initially, an assumption is made that the albedo of a local patch is a constant vector R. Thus, all vectors J(x) in the patch have the same direction of R. Then, it is assumed that the statistics of the surface shading ||J(x)|| and the transmission t(x) are independent in the patch. ICA estimates the direction of the constant vector R. It estimates the albedo of the scene and then estimates the medium transmission, under the assumption that the transmission and surface shading are locally uncorrelated. Fattal's approach which is physically sound can produce impressive results. Drawback of the system is, it is unable to handle heavy haze images. It may fail in the cases where the assumption is not valid.

Kaiming He and Tang [6] also proposed haze removal technique using single image. But, this technique depends on statistical assumptions. In recent years haze removal is carried out by using single-image processing method. In this method it is decided to replicate the Single image haze removal using dark channel prior. Kaiming He and Tang presented a paper based on dark channel prior concept in 2011. After referring this paper, haze removal technique uses in Single-Image which based on the concept of dark channel prior methods.

III. HAZE IMAGE DATASET

Haze images were collected from https://www.google.com/search?q=fog+images&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjnkM6FscrgAhWPfCsKHXmhALkQ_AUIDigB&cshid=1550668258784166&biw=1024&bih=657 . and given in fig3.

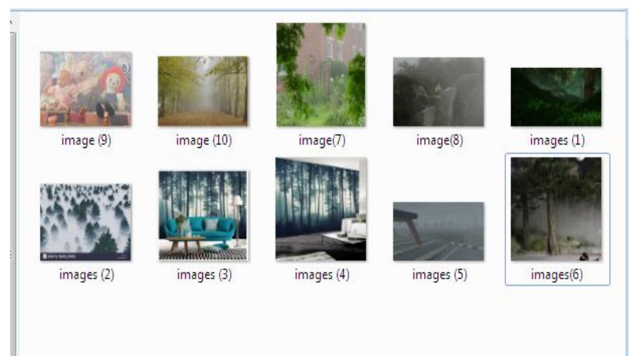

Fig 3 Dataset

IV. METHODOLOGY

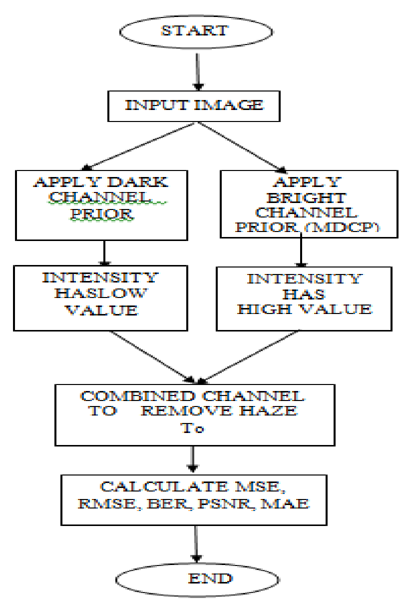

Fig. 4

V. HAZE REMOVAL METHODS

A. Dark channel prior

Dark channel prior method is used for single image dehazing. Here at least one color channel of an RGB image has some pixel of lowest intensities, which tends to zero [2].

When the pixels have lowest intensities or tendency to zero, the color diverges towards dark or black. This phenomena is Dark Channel and used it for image dehazing or to remove fog from natural outdoor images.

The dark channel of an arbitrary image *J* is given by Eqn (1)

$$J^{dark}(x)=\min_{c\epsilon\{rgb\}}(\min_{y\epsilon\Omega(x)}(J^{c}(y))) \qquad (1)$$

Where J^c is a color channel of J and Ω(x) is a local patch centered at x. The intensity of J^{dark} is low and tends to be zero, if J is a haze-free outdoor image brighter than its haze-free version where the transmission *t* is low. Hence, in regions with denser haze the dark channel of the haze image have higher intensity. Visually, the intensity of the dark channel is approximated by the thickness of the haze. In a haze-free image, dark channel may have high intensity. By subtracting a constant value corresponding to the darkest object in the scene, the spatially homogeneous haze is removed.

B. Bright channel

Image enhancement technology are commonly used in image processing to enhance low illumination color images. In this study, a brightness enhancement algorithm based on the bright channel prior, which focuses on the gray removal, has been proposed. The local patches in sufficient illumination images contain some pixels that have very high intensities in at least one color channel. Using this with haze imaging model, image enhancement can be achieved.[4]

The proposed median DCP(MDCP) is constructed as Eqn (2).

$$\theta_M(m,n) = \underset{k,l\in\Omega(m,n)}{med}\left(\min_{c\epsilon(r,g,b)}\frac{x(k,l,c)}{a(c)}\right) \qquad (2)$$

Likewise, the MDCP method initializes transmission t_M(m,n) by Eqn (3)

$$t_M(m,n)=1-\omega\theta_M(m,n) \qquad (3)$$

With ω set to 0.95 for our experiments. The recovered dehazed image using the MDCP is Eqn (4)

$$x_M(m,n)=\frac{x(m,n)-a}{\max(t_{M(m,n)},\epsilon)}+a \qquad (4)$$

Similar to the previous consideration for the equation is simplified by assuming that there is only one color channel.

$$\theta_m(m,n)= \underset{k,l\in\Omega(m,n)}{med}\left(\frac{x(k,l)}{a}\right) \qquad (5)$$

$$= \underset{k,l\in\Omega(m,n)}{med}\ x(k,l)t(k,l)/a+1-t(k,l) \qquad (6)$$

Eqn (5) (6) is take a look at how the MDCP method compares with the DCP method at occlusion boundaries[5].

C. Combine channel

In order to get quality Dehaze image combine Dark channel AND Bright Channel method. Output shown is fig4

Fig 5 Dehazed image

VI. EXPERIMENTAL RESULT

For experimentation and implementation the proposed technique is evaluated using MATLAB tool 2014a. The evaluation of proposed technique is done on the basis of following parameters.

1. Output

Fig 6. Input image

Fig 7 Dark channel

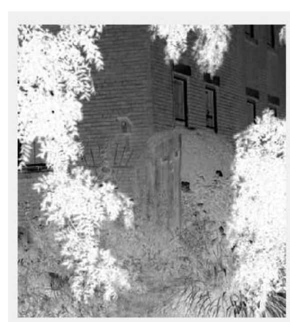

Fig 8. Bright channel

Fig 9 Output image

2. Output

Fig 10 Input image

Fig 11 Dark channel

Fig 12 Bright channel

Fig 13 Output image

A. MSE (Mean Square Error)

Mean square error will be to compute indication through subtracting quality indication through the reference, after which it computing the standard power in the blunder signal[6]. It can be explained as Eqn (7)

$$MSE=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(f(i,j)-f'(i,j)\right)^2 \quad (7)$$

Table 1Performance Measurement of MSE

IMAGES	MSE
Image 1	1.6805
Image 2	2.5609
Image 3	2.3195
Image 4	2.2982
Image 5	2.5019
Image 6	2.1883
Image 7	2.4687
Image 8	2.2741
Image 9	2.6785
Image 10	2.3914

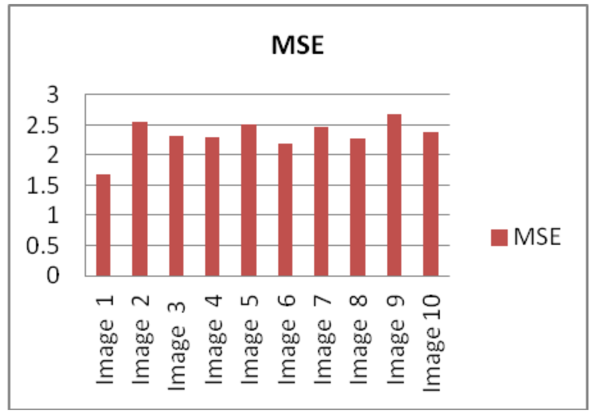

Fig 14 Graphical representation MSE for various haze image

B. RMSE (Root Mean Square Error):

Root-mean-square error can be a measure on the differences between valuations forecast by means of one or maybe estimator as well as valuation basically observed[6]. It can be explained as Eqn (8)

$$RMSE=\sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(f(i,j)-f'(i,j)\right)^2} \quad (8)$$

Table 2 Performance Measurement of RMSE

IMAGES	RMSE
Image 1	1.2963
Image 2	1.6002
Image 3	1.5230
Image 4	1.5160
Image 5	1.5817
Image 6	1.4793
Image 7	1.5709
Image 8	1.5082
Image 9	1.6366
Image 10	1.5464

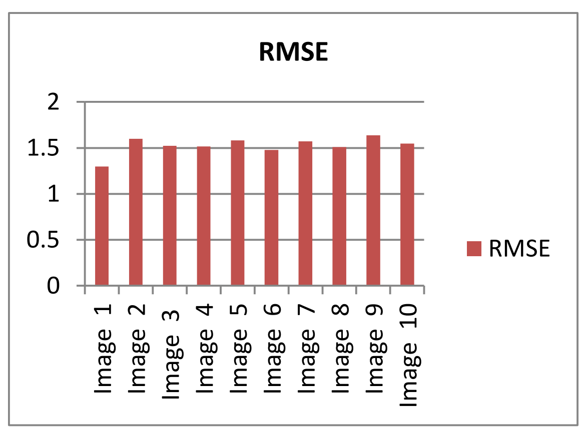

Fig 15 Graphical representation MSE for various haze image

C. BER (Bit Error Rate):

It defined as the rate in which faults arise inside of a transmission system. This really is immediately converted into the quantity of fault of which arise inside of a chain of a mentioned variety of bits [6]. The definition of bit error rate can be translated into a simple Eqn (9)

$$BER=\frac{Number\ of\ errors}{Total\ number\ of\ bits\ sent} \quad (9)$$

Table 3 Performance Measurement of BER

IMAGES	BER
Image 1	0.4833
Image 2	0.7394
Image 3	0.875
Image 4	1
Image 5	0.5618
Image 6	1
Image 7	1
Image 8	0.6667
Image 9	0.722
Image 10	0.6724

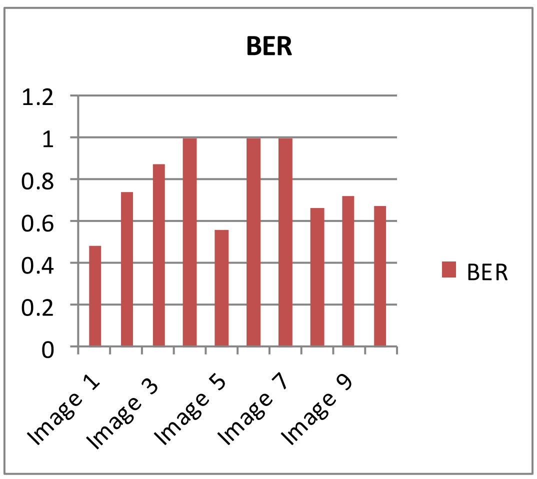

Fig 16 Graphical representation BER for various haze image

D. PSNR (Peak Signal-to-Noise Ratio):

The PSNR block computes the peak signal-to-noise ratio between two images in decibels. This ratio is often used as a quality measurement between the original and compressed images [6].

PSNR is used to assess the improvement in the quality of the Eqn (10)

$$PSNR=10\log_{10}\left[\frac{L^2}{MSE}\right] \quad (10)$$

Table 4 Performance Measurement of PSNR

IMAGES	PSNR
Image 1	45.87
Image 2	44.04
Image 3	44.47
Image 4	44.51
Image 5	44.14
Image 6	44.72
Image 7	44.20
Image 8	44.56
Image 9	43.85
Image 10	44.34

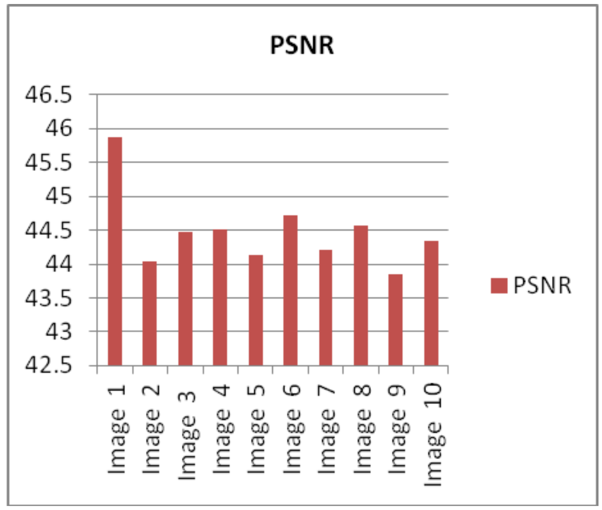

Fig 17 Graphical representation PSNR for various haze image

E. Median Angular Error:

The angular error e is defined as the angular distance between the algorithm estimate of the light source (ee) and the true illuminant vector (el) in normalized[6].

$$\varepsilon = \cos^{-1}(e1.ee) \quad (11)$$

This is the Eqn (11) which calculates the angular error.

Table 5 Performance Measurement of MAE

IMAGES	MAE
Image 1	0.541
Image 2	0.7394
Image 3	0.875
Image 4	1
Image 5	0.5618
Image 6	1
Image 7	1
Image 8	0.6666
Image 9	0.733
Image 10	0.6727

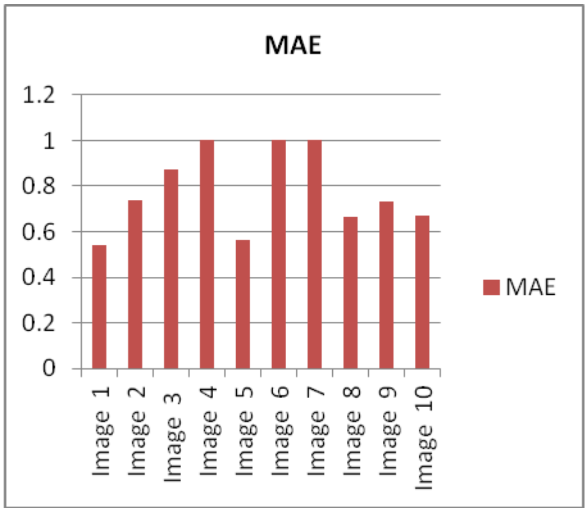

Fig 18 Graphical representation MAE for various haze image

VII CONCLUSION

In this paper, a simple technique called dark channel prior with median filter dark channel prior method was applied to remove image haze. While combining both methods, it gives better result. The performance measurement such as MSE, RMSE, BER, PSNR and MAE has been measured.

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