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A Comparative analysis of Image Dehazing Techniques for Halo Effect Suppression

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***Abstract*— This paper provides a comparative study of the various dehazing techniques. Due to the presence of smoke, fog, rain and so on, the nature scenes and outdoor pictures taken at harsh weather are degraded. Scenes of nature taken during bad weather have low contrasts, colors and artifacts. This can also cause trouble identifying the objects in the captured images. This analysis presents details on various image dehazing methods that aid in removing haze from the captured hazy images (shortly on polarization and dark prior channel techniques). There is growth in contrast, visible range, and loyalty to color. These methodologies are commonly used in many applications such as outdoor surveillance, tracking of artifacts, underwater images, military, etc.**

***Keywords*— Polarization, dark prior channels, improved dark prior channel, air-light, direct attenuation, transmission map.**

I. INTRODUCTION

Outdoor images are usually stripped of atmospheric particles such as snow, water droplets, etc. So in bad climatic situations, the color and brightness of the captured image have a consequential degradation. Haze is an atmospheric phenomenon that unclear the sky. All the particles in the atmosphere are within a range below 1000 meters [1]. Atmospheric particles include fog, smoke, water droplets, dust etc. Haze is caused by dispersed, atmospherically suspended particles. It happens in many urban areas and in manufacturing zones. It should have affected image quality instead of haze. Haze is a combination of two elements. When taking the outdoor shot during poor weather conditions, the radiance produced by the camera from the scene is dimmed along the line of sight [2]. The particles that are present in have the character of absorbing light and radiating light in all directions because of the hazy setting. The picture adds whiteness. And the second element of Attenuation is the cancelling out of intensity. Since it is attenuated along the sightline, the color is greatly fading due to this. The amount of the dispersal depends on the distance between the scene and camera points. Therefore the spatially dependent degradation is directly proportional is the distance and the sum of light scattering [3].

Haze = Attenuation + Airlight

II. HAZY IMAGE FORMATION MODEL

The picture arising in the presence of poor atmospheric. Due to the presence of substantial particles in the atmosphere which have a significant size between 1-10 μm, the image quality degrades., Those atmospheric particles absorb and scatter the light coming from a sensor. Assume that the model of that haze is linear. Only the pixel location is modified from the linearity description within this model. Fog is Airlight and Direct Attenuation combination. Two basic phenomenon's occur this invisibility, direct attenuation and airlight [1,3].

$$I(y) = J(y)*t(y) + A*(1-t)$$

I (y) - Observed image intensity of the yth pixel
J (y) - The scene radiance (the true color that we want to recover)
A – Atmospheric light
t - Transmission medium describing the portion of the light that is not scattered and reaches directly to the camera.
$t = e^{(-z*\beta)}$
The transmittance depends on the distance z between the target and camera, and the β is atmospheric attenuation.
In the equation first term,
J(y)*t - Direct attenuation.
The second term,
A*(1-t) - Airlight.

This haze model is directly extended to each RGB component of a color image. In the haze, the air-light is often partly polarized [4]. Therefore, we can change according to it in the imaging system by putting up a polarizing filter at an angle α. There is an orientation when spinning the polarizer, under which the picture is least intense. Let's denote that image as min. I(y). Suppose polarization is only correlated with the air-light. If so, then I(y) min represent to the lowest air-light number. Therefore, this is the figure with the highest brightness that optical filtering can achieve. They denote this optimal orientation of the polarizer as being θ. 9 We can then change the orientation of the polarizer by 90 ° relative to θ.. This time, the image irradiance is strongest as we sense the air-light 's principal component of polarization. Denote the picture as max I(y). Once these images are acquired, describes dehazing of the scene as estimating [4].

J(y) = (I(y) – A') / t'

t' is estimated transmittance

t' = 1− (A' / A)

A' = (I(y) max –I(y) min) / p

A' is the estimated air-light.

P is the degree of air-light polarization. (Polarization degree is measured as the fraction of total power borne by the polarized wave component)

A 'is determined from the crude picture by looking at pixels at infinity that represents the objects. We allocate certain pixels to the sky close to the horizon [5].

p = (I(y)max –I(y)min) / (I(y)max+I(y)min) at z=∞ .

Similarly, the air-light saturation value is estimated from the same sky area as

A =[I(y)max +I(y)min] at z=∞ .

Based on the above equations, a scaled distance map of the scene is recovered

β z = − log [1− A'/ A] .

This operation is done in each color channel separately

III. METHODS TO DEHAZE

A) POLARIZATION FILTER

Using a polarization filter from the hazy images, Haze can be extracted by multiple image methods. Different input images of the same scene taken during different bad weather conditions are in this process. Assume the Airlight is scattered for the use of the polarization filters. The scattered light in all directions is called unpolarized light as shown in figure (1).

Figure 1: Unpolarized Light

From the figure (1), when it is passed through polarization filter only one plane of light enters into the camera depending on the orientation of the polarization filter which is mounted on our cameras [6].

Fog cannot be separated from images by the polarization filter alone. The input picture in this process is a mixture of 2 unknown components. The first is the radiance of the scene in the absence of the fog and the other is Air-light. This method does not need to change the weather conditions and can be used at any time. Another method for achieving the best result is the use of two polarized frames and post-processing (it is nothing more than editing the image taken). The visibility seems to be much higher, so the problem seems to be fixed. This approach necessitates additional hardware and effort [7].

B) DARK CHANNEL PRIOR

A single method of dehazing an image is used with the prior dark channel. This is used to calculate the haze-free image statistics for outdoors. This method assumes that certain pixels are of very low intensity in every one of the color channels. But in this case, the low-intensity area of pixels is detected and further process is completed. Such regions of pixels are considered dark pixels. A dark channel is described as follows, based on that observation [5,7].

$$\mathbf{Jdark\ (x)} = \min_{\mathbf{y \in \Omega(x)}} \left(\min_{c \in \{r,g,b\}} jc(y) \right)$$

They use these mysterious pixels to estimate the transmission route. When the transmission map is calculated, a refined transmission map is calculated to minimize any blocking impact. The purpose of this technique is to restore the picture to fog-free. Through this approach, Single image is used to restore the foggy image and to estimate the transmission map accurately [5].

CALCULATIONS

The rgb digital image I which is deduced can be described as:

$$I(x,y) = J(x,y)t(x,y)+A(1-t(x,y)), \quad (1)$$

where x ,y is a pixel position,

I(x, y) = (I ^ r (x ,y),I ^ g (x ,y), I ^ b (x ,y)) is the rgb observed pixel

A = (A ^r ,A ^g ,A ^b)

is the global rgb environmental airlight.

t(x,y) is the transmission of scattered light, in a homogeneous medium,

which can be described as:

$$t(x,y) = e^{(-\beta\, d(x,y))} \quad (2)$$

where β is a constant associated with the weather condition

d(x,y) is the depth of the scene of every x,y of I.

Finally,

J(x,y) = (J ^r (x,y), J ^g(x,y), J ^b(x,y)) is the estimation of a pixel with position x, y of a picture J which has the data of the scene without gestures.

Then, to get back J(x,y),

Equation 1 can be expressed as:

$$J(x,y) = I(x,y)-A\, t(x,y) + A \quad (3)$$

The difficulty in retrieving the image J lies in the fact that parameters t(x, y) and A are unknown. In (8) the dark channel (DC) presents a very powerful technique for calculating the unidentified variables.

The DC is defined as:

$$I^{dark}(x,y) = \min_{c\in(R,G,B)} \min_{z\in\Omega(x,y)} I^c(z) \quad (4)$$

where sigma (x,y) is a squared window of size l×l defined as,

$$\Omega(x,y) = I^c(x-k, y-k) \quad (5)$$

where k=[−⌊L/2⌉ …⌊L/2⌉] , k∈ N ,in this paper the size L of sigma(x ,y) used is15.

The dark channel prior (DCP) consists of the following statement:

In a non-sky region, the dark channel of a haze free region has a low value,

i.e.: $I^{dark}(x,y) \to 0 \quad (6)$

To compute t(x ,y),in (8) the Equation 1is normalized according to the airlight A by:

$$I(x,y)/A = [J(x,y)/A]^* t(x,y) + 1 - t(x,y) \quad (7)$$

Applying the dark channel in both sides of the equation 7

$$\min_{c\in(R,G,B)}\{\min_{z\in\Omega(x,y)}[I(x,y)/A](z)\} = \min_{c\in(R,G,B)}\{\min_{z\in\Omega(x,y)}[J(x,y)/A(z)]\}^* t(x,y)+1-t(x,y)$$

since J(x ,y) is the haze-free image, then:

$$J^{dark}(x,y) = \min_{c\in(R,G,B)}\{\min_{z\in\Omega(x,y)} J(x,y)/A(z)\} = 0 \quad (8)$$

Substituting

$$\min_{c\in(R,G,B)}\{\min_{z\in\Omega(x,y)} I(x,y)/A(z)\} = 1-t(x,y),$$

Then the dark channel and the transmission are related as:

$$t(x,y) = 1-w \min_{c\in(R,G,B)} \min_{z\in\Omega(x,y)} I(x,y)/A(z) = 1 - w^* I^{dark}(x,y)$$

where w=[0...1] is an attribute that constitutes the recovery level; the value used was w=0.95

In this work, we empirically described the optimum value w for our system is 0.85. The air-light A is assumed constant in all images and is calculated by first choosing 0.01% of the map created when measuring the dark path. The one with the maximum strength in the image I input is selected from the selected pixels, and that value is assigned to A [6,9].

C) IMPROVED DARK CHANNEL PRIOR (IDCP)

Figure 2 gives a diagram of the results if the dim channel is utilized legitimately to reestablish the picture so as to clarify the reason for the antiques created when the dull channel earlier is applied. In Figure 2 the info picture I is shown with two windows (p1) and (p2) with size l = 3 focused separately in the pixels p1 and p2. While the Ω1 (p1) window is found in a homogeneous field, the Ω2 (p2) window is situated in a area close to an edge. (depending on the size of Ω2). The anticipated dim divert is appeared in Figure 2 b, where the pixels p1 and p2 have various qualities since they have a place with various locales. Figure 2c shows the dim channel got utilizing Equation 4 where the estimation of pixel p1 is resolved accurately; be that as it may, the estimation of pixel p2 is lower than the normal worth; this is on the grounds that in any event one pixel component in window Ω2(p2) is lower than the pixel p2. It is the reason for antiquity age close to the edges when recovering picture J(x, y) (Figure 2d) [4,9].

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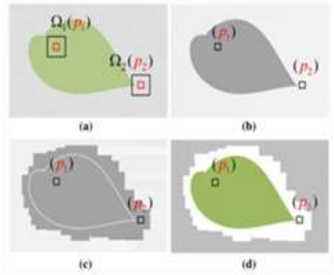

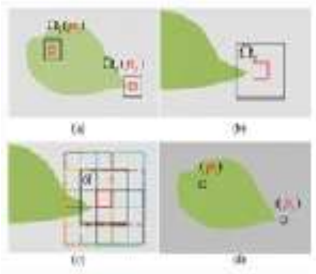

Fig 2: Classic DCP Algorithm Fig 3: Modified DC

In the proposed technique, at first I dark is a one-channel picture with a similar size of I, and all the components I dark(x,y) are zero. We characterize α as a square window with size l where every one of its components have the estimation of I dark(x,y) registered by Equation 4 [9]. Then:

$$\text{I dark } (x-\lfloor L/2\rfloor ... x+\lfloor L/2\rfloor, y-\lfloor L/2\rfloor ... y+\lfloor L/2\rfloor) = \text{pixel-wise max } (\alpha(1...L),(1...L), \text{I dark } (x-\lfloor L/2\rfloor ... x+\lfloor L/2\rfloor, y-\lfloor L/2\rfloor ... y+\lfloor L/2\rfloor))$$

A correlation of the data utilized for any pixel (x , y) is shown in Figure 3 between the classic DC and the modified DC for L=3.

The outcomes deduced using the modified DC is shown in figure 4, where the resulting artifacts have significantly decreased compared to the classic DC. The maximum pixel-wise operation in the proposed modified DC permits has any pixel(x, y) neighborhood information about the previous assignment in I dark. A more reliable and accurate approximation of the DC estimation is obtained in heterogeneous regions (near edges), since the underestimated values are reduced with the full pixel-wise activity. Inhomogeneous regions (far from edges), the impact of the pixel-wise maximum operating values is basically unmodified, as neighbors I dark are identical in these regions [10].

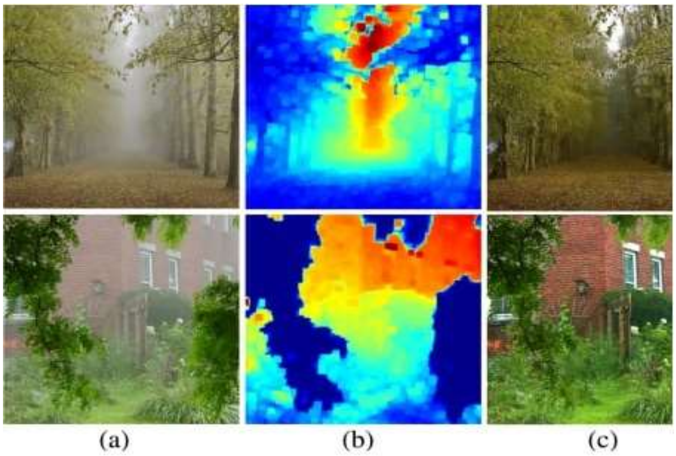

Fig 4: a) Actual Hazy Input b) Obtained from DC map c) Result

COMPARISON

The benefit of using Polarization filter is the elimination of fog and the haze-free image does not have Halo effects. Several images of the same scene and different weather conditions are needed to apply this technique however. Single image is needed for haze removal in the previous dark channel and transmission map is also calculated correctly. But the downside to this strategy is that it creates certain halo effects on the resulting images and this process is also not valid when the scene object is close to Airlight, such as car headlights, snowy ground etc. In Modified Dark Channel Algorithm, air light estimation is accurate and the complexity of soft matting is not required for refined transmission. The downside of this algorithm is that in some regions it generates halo effects; the map of transmission isn't accurately calculated.

IV. CONCLUSIONS

This paper provides the basic knowledge of images captured in hazy weather conditions, differences between clear day image and hazy image, dehazing methods (polarization method, dark channel prior), and differences between the dark prior channel and modified dark prior channel. In modified DC, computation time is requiring less and also sky regions become bright and smoother

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