International Journal of Research in Advent Technology, Vol. 3, No.6, June 2015
E-ISSN: 2321-9637

Visibility Restoration by Dehazing in Intelligent Transportation System

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Abstract-Restoration of the images those are corrupted due to various degradations is one of the critical problems in the field of image processing. Bad weather conditions such as fog cause degradation of captured road scene images. Also the headlight of vehicle and streetlights in night makes the image looks blurred. Fog and sandstorm are some phenomenon's that causes the localized light problems and colorshift problems respectively. Due to the presence of these atmospheric particles there is a resultant decay in the color and contrast of the captured image in the bad weather conditions. This may cause difficulty in detecting the objects in the captured hazy images or scenes. Dark channel prior works on the basis that most local patches contain some pixel with very low intensity in atleast one color channel. Using this, the thickness of the haze can be directly estimated and high quality haze free image can be recovered. An improved method of Dark channel is used called the Hybrid Dark channel method to increase the efficiency of restoration. The stability and robustness of the system can be improved by effective haze removal algorithm.

Index Terms- Dehazing, Hybrid Dark Channel, Image Restoration.

1. INTRODUCTION

The images captured on road scenes can be degraded due to the presence of haze, fog, sandstorms etc. This visibility degradation of images is due to the absorption and scattering of light by atmospheric particles. During night time, the headlights of the vehicle and the street lights also cause the localized light effects. The light incident and reflected by an object is scattered due to the presence of water droplets, fog etc. present in the atmosphere. Fog is a natural phenomenon that reduces the image quality and cause blur. Fog is mainly the combination of airlight and direct attenuation. It degrades the picture quality and reduces the performance of video surveillance, tracking and navigation.

Another cause for degradation of road images is the presence of sandstorms. In sandstorms, the dust particles in the atmosphere absorb the color in the spectrum causing color shift problem in the images. So the drivers cant clearly see what is in front of him, resulting in road accidents. Road image degradation also causes problems in intelligent transportation systems such as traveling vehicle data recorders and traffic surveillance systems. Most of the road accidents are due to the bad weather condition, since the drivers are unable to visualize the road situations. So improved traffic safety is needed to be provided to reduce this problem by good highway visibility methods. Also, the amount of absorption and scattering depends on the depth of the scene between the camera and a scene point. Therefore, scene depth information is important for recovering scene radiance in images of hazy environments. Haze removal is highly desired not only in road security but also in consumer and computational photography and other computer vision applications. Removing haze can significantly increase the visibility of the scene and correct the color shift caused by the airlight. The goal of haze removal algorithms is to enhance the image and to recover the detail of original scene from the hazy image.

2. VISIBILITY RESTORATION TECHNIQUES

Image restoration is the process of enhancing and restoring the degraded image into good quality image. Visibility restoration reduces or removes the degradation that occurred on the image due to various factors such as blur, camera movement, fog, haze etc. There are several methods to restore the image. Some early method uses multiple image restoration where more than two images is needed for restoration. The later methods use single image restoration techniques. Some methods just increase the contrast of the image [2],[3]. And some other methods use the pixels to restore the image. The Pictorial representation of foggy image is shown below. In this paper image restoration using hybrid dark channel prior method is discussed.

2.1. *Dark Channel Prior*

To restore the image from foggy image, we need to estimate the value of atmospheric effect also known as airlight. Dark channel prior [8] is used for the estimation of atmospheric light effect, It works based on the assumption that some pixels have very low intensity in atleast one color channel. So it can be

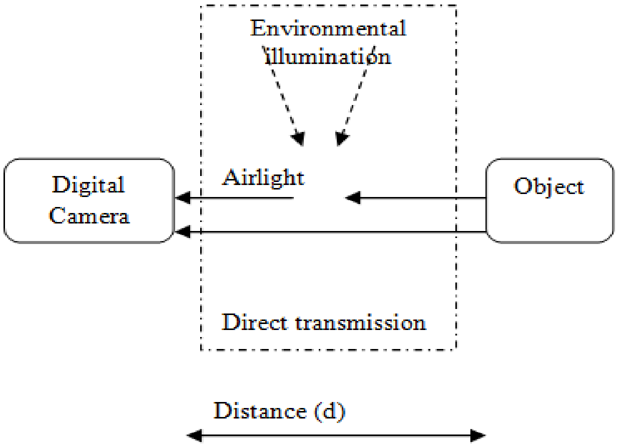

Fig. 1. Pictorial representation of the foggy or hazy image

mainly used in most non sky patches. The low intensity in images is due to the presence of

- Colorful items or surfaces (trees, bright colored objects)
- Shadows (shadow of vehicle or object)
- Dark items or surfaces (stones etc.)

Due to the presence of fog, the hazy image has higher brightness compared to original image. So when haze or fog increases, the brightness of image also increases. The dark channel values are calculated in each pixel. The pixel containing haze is white in color and which containing object is black in color. For calculating the values, first transmission map and atmospheric light estimation is done using the methods listed below.

2.2. *Optical Transmission*

The image captured from road scene will contain original image and the dust or foggy particles. In optical model, it can be represented in equation form as

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

where I(x,y) represents the captured image, J(x,y) is the original haze free image, A is the atmospheric light and t(x,y) is the transmission map. J(x,y)t(x,y) represents the direct attenuation in the medium. A(1-t(x,y)) represents the airlight that leads to color shift problems. The transmission map can be expressed as

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

where β is the atmospheric attenuation coefficient and d(x,y) is the scene depth that represents distance between the image captured and digital camera. The figure representing the environmental illusions is given below. In this, the atmosphere contains dusty particles that results in the attenuation and transmission of object particles. It shows that the vision get blurred due to scattering and attenuation of dust particles in the atmosphere. The input can be taken from either digital camera or sensors which are available.

The dark channel value is represented by J^{dark}. It is the dark channel value for different pixels in the captured image. It can be found by the equation given below.

$$J^{dark}(x,y) = min_{(i,j)\in\Omega(x,y)}\,(min_{c\in\{r,g,b\}}\,J(i,j)) \qquad (3)$$

where $c\in\{r,g,b\}$, J denotes a color image, Ω represents a local patch centered at (x,y). If J^{dark} value is black, it represents the object and if it is white, it means that haze is present in that region. For a haze free image, dark channel value is zero. Hazy image has higher intensity. This property is used to estimate the transmission and atmosphere light. Block diagram of DCP Algorithm is given in Fig. 2.

Bilateral filter considers spatial relationship of pixels and also similarity reaction of brightness value for pixels. It has the advantage of making the image smoother and clearer than other filter methods. The input Hazy image is processed using Hybrid Dark Channel Prior method. Using that, the dark pixel is estimated for different patch sizes. The dark channel estimation consists of finding the transmission map and atmospheric light estimation (also called airlight estimation) of the image. The procedures for finding both the transmission map and atmospheric estimation are listed below.

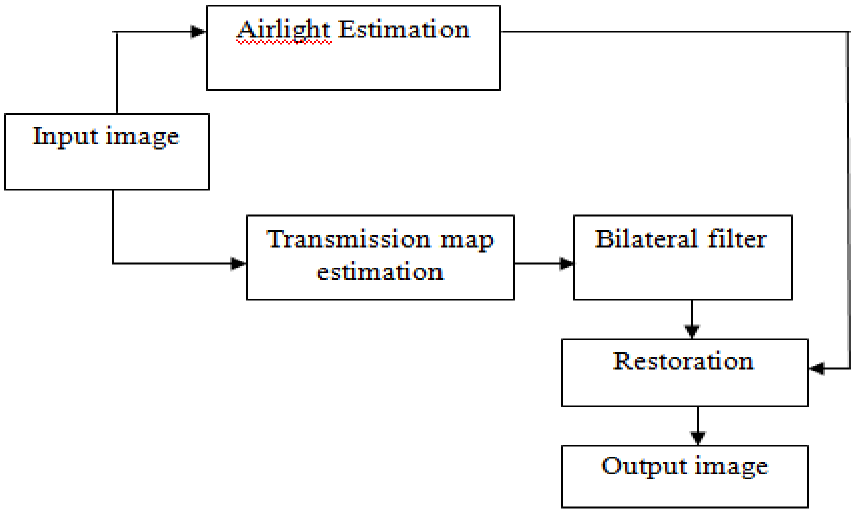

Fig. 2. Block Diagram of DCP Algorithm

2.2.1. *Estimation of the transmission map*

For the estimation of transmission map, the equation for haze removal by atmospheric light A is normalized by dividing the Eq. (1) by A. Hence the Eq. (1) can be written as,

$$\frac{I(x,y)}{A} = \frac{J(x,y)}{A} t(x,y) + 1 - t(x,y) \qquad (4)$$

where I(x,y) is the intensity of the hazy image and t(x,y) is the transmission map. Take Ω(x,y) as constant, the dark channel can be calculated. As J is haze free image, the dark channel of J is close to 0. Then the above equation can be written as,

$$min_{(i,j) \in \Omega(x,y)} \left(min_{c \in \{r,g,b\}} \frac{J(i,j)}{A} \right) = 0 \qquad (5)$$

The transmission map can be written as

$$\tilde{t}(x,y) = 1 - min_{(i,j) \in \Omega(x,y)} \left(min_{c \in \{r,g,b\}} \frac{I(i,j)}{A} \right) \qquad (6)$$

If all the haze is removed fully, the image appears somewhat unnatural. So to maintain the effect of natural scene, a small amount of haze is maintained by introducing a constant parameter ω. Thus, we can write the Eq. (6) as

$$\tilde{t}(x,y) = 1 - \omega \, min_{(i,j) \in \Omega(x,y)} \left(min_{c \in \{r,g,b\}} \frac{I(i,j)}{A} \right) \qquad (7)$$

The value of ω is taken as 0.95, the value close to 1 to maintain a small amount of haze. The most optimal small patch size of the image is taken as 3 × 3, and the most optimal large patch size is taken as 45 × 45.So taking average, a patch size of 15x15 is used. The values of atmospheric light A is the highest intensity pixels in each RGB channel of the original input image according to its correspondence to the brightest 0.1% of pixels in the dark channel image.

2.2.2. *Recovering the scene radiance*

Finally, a single hazy image I can be recovered from scene radiance J as

$$J(x,y) = \frac{I(x,y) - A}{max\,(t(x,y), t_0)} + A \qquad (8)$$

where c ∈ {r, g, b}, the value of t_0 is assumed to be 0.1, I(x,y) is the captured image that contains haze, the value of t(x,y) is calculated from the above equations. That value is compared with 0.1 and the highest value is taken in the denominator. A is the atmospheric light value.
Using the equations given above, first the atmospheric light is estimated. And then the transmission map is estimates. Transmission map is defined as the amount of light that reaches the camera without scattering. This can be found using the Eq. (7). After finding these values the image is filtered using bilateral filter to remove the unwanted noises and blur. Bilateral filter is chosen since it prevents the edges of image more than other filters. Then the image is restored after removing all the degradation and fog. The block diagram of Dark Cannel Technique is shown below in Fig. 2. The restoration can be made effective by using Hybrid Dark Channel Prior instead of Dark Channel Prior. The proposed method is discussed in details in the next sections.

3. PROPOSED METHOD

In section A, the DCP method is analyzed. If the image has low contrast and large background area, DCP method will obtain an indistinct and dim result. So to avoid the effects of artifacts and to recover true color, a method based on improve DCP is proposed, called the Hybrid dark channel prior (HDCP) method. HDCP module ensures correct atmospheric light estimation and the subsequent avoidance of halo effects during the haze removal of single images. The value of Dark channel is given by,

$$J^{dark}(x,y)=\frac{\alpha}{\alpha+\beta}min_{(i,j)\in\Omega(x,y)}\left(min_{c\in\{r,g,b\}}J(i,j)\right)+\frac{\beta}{\alpha+\beta}min_{(i,j)\in\mu(x,y)}\left(min_{c\in\{r,g,b\}}J(i,j)\right) \quad (9)$$

where J represents an arbitrary image under a wide range of weather conditions, J represents color image, Ω and μ represent local patches centered at (x, y), minc∈{r,g,b} J(i, j) performs the minimum operation on J, min(i,j)∈Ω(x,y) performs a minimum filter on the local patch centered at (x, y) using the small patch size, and min(i,j)∈μ(x,y) performs a minimum filter on the local patch centered at (x, y) using the large patch size. After calculating the haze density, the transmission map can be directly estimated as

$$t^h(x,y)=1-\frac{\alpha}{\alpha+\beta}min_{(i,j)\in\Omega(x,y)}\left(min_{c\in\{r,g,b\}}\frac{I^c(i,j)}{A^c}\right)-\frac{\beta}{\alpha+\beta}min_{(i,j)\in\mu(x,y)}\left(min_{c\in\{r,g,b\}}\frac{I^c(i,j)}{A}\right) \quad (10)$$

Inorder to maintain a constant amount of haze, the parameter ω is added as in the case of normal transmission map estimation. So the above equation becomes,

$$t^h(x,y)=1-\frac{\omega\alpha}{\alpha+\beta}min_{(i,j)\in\Omega(x,y)}\left(min_{c\in\{r,g,b\}}\frac{I^c(i,j)}{A^c}\right)-\frac{\omega\beta}{\alpha+\beta}min_{(i,j)\in\mu(x,y)}\left(min_{c\in\{r,g,b\}}\frac{I^c(i,j)}{A}\right) \quad (11)$$

where ω is a constant parameter to maintain a minimum number of haze, and can be set to 0.95. α and β are the constant factors for a small patch size and large patch size, respectively. Fig. 3. shows the block diagram of Hybrid Dark Channel Prior method along with the Color Analysis and Visibility Recovery section.

4. SIMULATED RESULTS

The performance of various defogging techniques can be estimated. Simulation is carried out in MATLAB simulation tool. Intel®core™2 duo processor is used. The patch size of 15x15 is used to analyze the dark channel value to remove haze. The simulated results for processing of hazy images in different stages are given below. Figure 4.1 shows the input hazy image. The image is restored using Dark channel method by estimating the atmospheric light and transmission map.

Fig. 3.1. Input hazy image

Fig. 3.2. Estimated transmission map

Fig. 3.3. Refined transmission map after filter

Fig. 3.4 Final haze free image

Fig.4 a)Input hazy image b) Output using Dark Channel method c)Output using proposed method.

5. CONCLUSION

In this paper, an approach based on HDCP technique for haze and fog removal in single image capture under bad weather conditions is proposed. It estimates the localized light source and atmospheric light effect. It also eliminates the artifact effect present in the images. This method works effectively than other traditional methods for fog and noise removal under different weather conditions. This technique can be modified to track the vehicle number using segmentation and can use this technique to enhance the video also.

Acknowledgments

We are thankful to our guide Dr. S. V. Manisekaran for the guidance and encouragement for the project. The authors are grateful to express sincere thanks and gratitude to our Department of Information Technology.

REFERENCES

[1] Schechner, Y.; Narasimhan, S. G.; Nayar, S. K. (2001): Instant dehazing of images using polarization. IEEE Computer Society Conference on Computer Vision and Pattern Recognition, pp. 325-332.

[2] Narasimhan, S. G.; Nayar, S. K. (2003): Contrast restoration of weather degraded images. IEEE Trans. Pattern Anal. Mach. Intell., vol. 25, no. 6, pp. 713–724, Jun. 2003.

[3] Nayar, S. K ; Narasimhan, S. G.(1999): Vision in bad weather. In Proc. 7^{th} IEEE Int. Conf. Comput. Vis., pp. 820–827.

[4] Tan, R. (2008): Visibility in bad weather from a single image. IEEE conference on Computer Vision and Pattern Recognition, pp. 1-8.

[5] Fattal, R.(2008): Single image dehazing. International Conference on Computer Graphics and Interactive Techniques archive ACM SIGGRAPH,pp. 1-9.

[6] He, K.; Sun, J. Tang, X.(2009): Single image haze removal using dark channel prior. IEEE International Conference on Computer Vision and Pattern Recognition, pp. 1956-1963.

[7] Fang, S.; Zhan, J.; Cao, Y.; Rao, R.(2010): Improved Single Image Dehazing Using Segmentation. IEEE International Conference on Image Processing (ICIP), pp. 3589-3592.

[8] Tarel, J. P.; Hautière, N.; Caraffa, L; Cord, A.; Halmaoui, H.; Gruyer, D. (2012): Vision enhancement in homogeneous and heterogeneous fog. IEEE Intell. Transp. Syst. Mag., **4**(2), pp. 6–20.