REVIEW ON DEHAZING BASED ON ATMOSPHERIC SCATTERING MODEL

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Abstract: Haze is an annoying problem in computer vision and computer applications. Haze removal is one of the important research areas in image processing. Haze is an atmospheric phenomenon in which dust, smoke and other particles degrades the clarity of the sky. Haze is a combination of air light and attenuation process. Air light increases the whiteness of the image and attenuation effect reduces the contrast. De-hazing mainly enhances contrast of the images. Haze removal algorithms are used to improve visual quality of an image. De-hazing is a difficult task and which depends on unknown scene depth map information. This paper reviews various haze removal algorithms based on atmospheric scattering model used in many image processing applications.

Index Terms - **Haze Removal, Image Restoration, Atmospheric Scattering Model, Quad Tree Splitting, Dark Channel Prior.**

I . INTRODUCTION

Haze is an environmental phenomenon, which is produced by dust, smoke and other dry particles in the atmosphere and it affects the clarity of the sky. Images taken in bad weather conditions may degrade the quality of images. Bad weather conditions like haze, mist and fog affect the color and contrast of images. While capturing outdoor scenes it is a serious difficulty for photographers. Bad weather conditions also affect the quality of satellite and under water images.

For many reasons, de-hazing has become an important and urgent research problem in the field of computer vision. Degradation of image visibility can affect different systems like weather condition systems, outdoor object recognition systems, remote sensing systems, intelligent transportation systems such as traveling vehicle data recorders and traffic surveillance systems. Dehazing mainly enhances contrast of images. The nature of the haze is unpredictable. Its effects may vary across the scene. It means that the modeling of real haze is not always appropriate. Haze removal algorithms are used to improve visual quality of an image. Dehazing is a difficult task as fog depends on the unknown scene depth map [1] information. Haze removal requires the estimation of air-light map or depth map. Dehazing methods can be divided into two categories: 1) Image enhancement 2) Image Restoration.
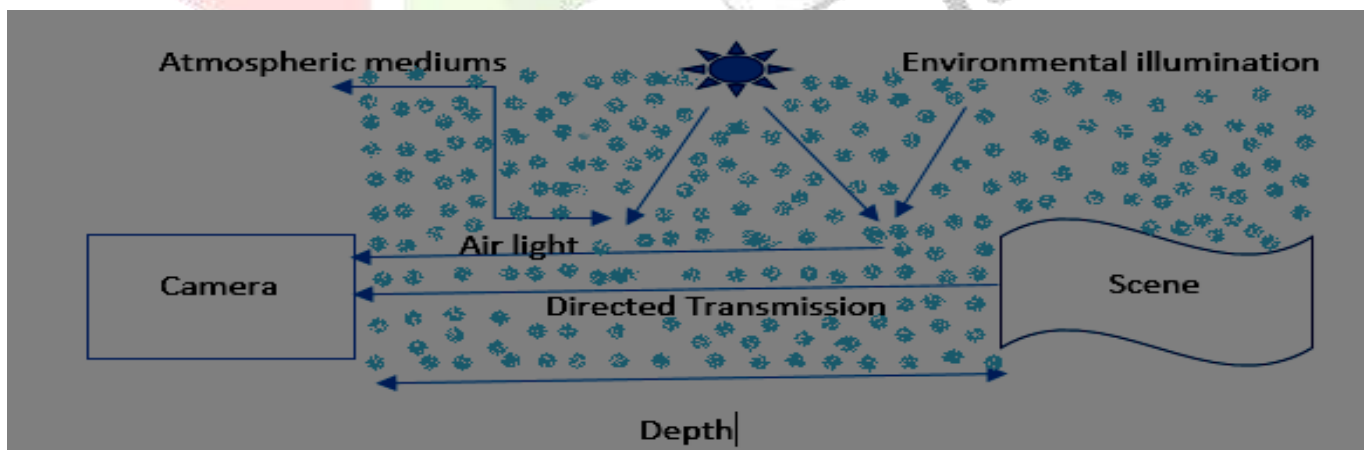

Fig.1.Atmospheric scattering model.

The Principal objective of image improvement is to process a given image in order that the result's a lot of suitable than the first image for a selected application. It accentuates or sharpens image options like edges, boundaries, or distinction to form.

A hazy image is obtained by using atmospheric scattering model [3]. According to atmospheric scattering theory, scattering of atmospheric particles is mainly divided into two. One is due to attenuation of reflected light from the object surface to the camera, other is scattering of Air light reaching to the camera.

The main objective of haze removal is to restore the haze free image J from the observed hazy image I. Therefore, the global atmospheric light A and the medium transmission t must be estimated.

$$I(x) = J(x). *t(x) + A.*[1- t(x)]$$

where x is pixel position, I is the observed intensity, that is the hazy image, J is the scene radiance, that is the haze-free image, A is the global atmospheric light, t is the medium transmission describing the portion of the light that can reach the camera, and .* represents the corresponding points multiplication. The term $J(x).*t(x)$ is called as direct attenuation which describes the scene radiance and its decay in the medium. The next term $A.*[1\ t(x)]$ denotes the air light [4], resulting from previously scattered light and leads to the shift of the scene colors.

The principle of the attenuation model is described in Fig. 2. If a beam of light is emitted into an atmospheric medium, when the incident light passes through a unit area (the shaded part), the energy of the light will then be attenuated.
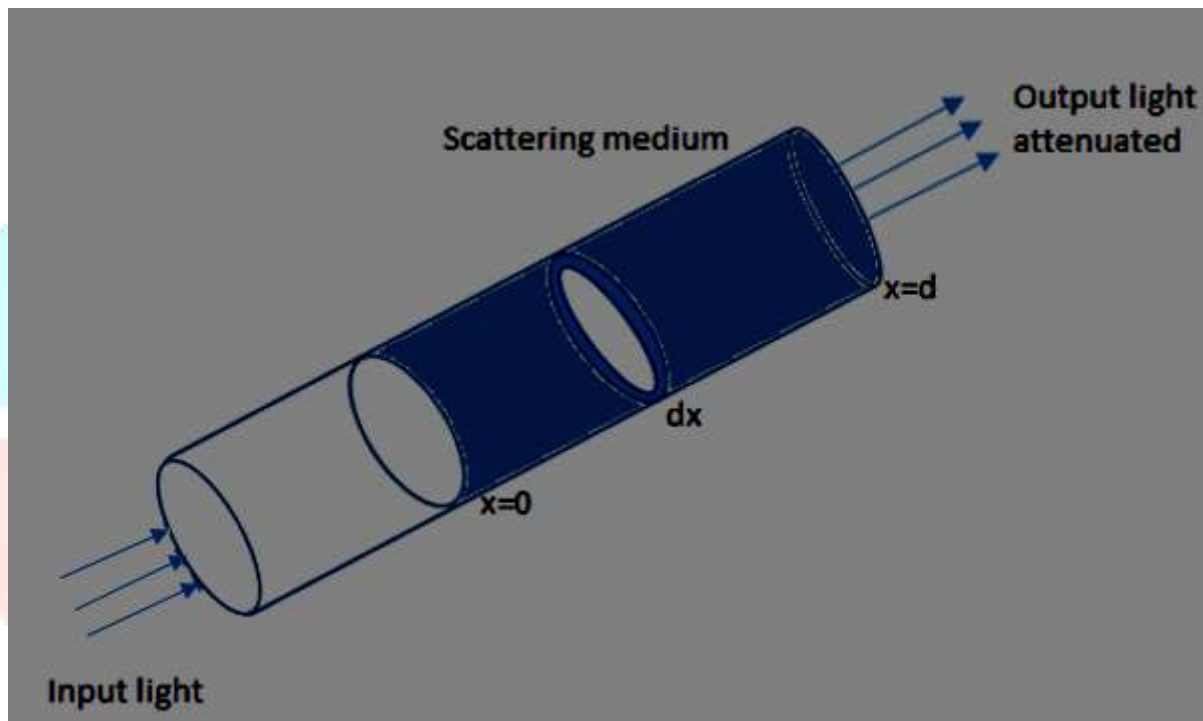

Fig. 2. Attenuation model.

It can be expressed by

$$E_d (d, \lambda) = E_0 (\lambda) e^\lambda d$$

Where λ, is the wavelength of visible light, d is the distance from the scene to the camera, $\beta (\lambda)$ is the atmospheric scattering coefficient and $E_0 (\lambda)$ is the beam radiation intensity at x = 0. Multiple image dehazing [5] and single image dehazing are based on atmospheric scattering model. Multiple images dehazing should require more than images of various climate conditions. So this strategy cannot adopt in real time. Therefore recent research works are methods based on single image dehazing. Jian [6] proposed a novel algorithm which uses minimum channel in R, G, B and difference of the three channels is used to estimate transmission map. Abiraha [7] proposed a framework based on color attenuation prior model. Here an adaptive linear model is introduced to recover depth information and thereby restore outlook radiance. Ju [8] proposed an improved method which divides input image into several scenes based on haze thickness. Transmission map is estimated by maximizing the contrast in each scene. Gayathri [9] put forward an approach which is based on local extrema, is used to restore hazy image. It is a edge preserving smoothing technique. Generally sky regions are detected based on Dark channel prior (DCP) [10], but in this method DCP cannot be used. Yuan [11] proposed an innovative idea initially; sky regions are segmented by quad tree splitting based feature pixels detection. A sky segmentation and region wised medium transmission techniques are used for haze removal. Sreektty [12] proposed a linear model which creates depth map information and recovering scene radiance. Wang [13] proposed a new method based on reflection coefficient in color image in which at least one reflection coefficient of the color component is very small. The numerator and denominator are calculated for three color channels with minimum filter. Bi [14] proposed a method in which transmission map are and brightness

map estimated using atmospheric light intensity. Finally image contrast can be improved by an unsharp masking algorithm. Liu [15] proposed an effective haze removal method which uses atmospheric veil. It is constant in local path morphological operator [16] and Dark Channel prior is used to find out initial atmospheric veil.

II. LITERATURE SURVEY

Jian et.al [6] proposed a novel method which uses the minimum channel in R, G, and B. The difference of this three channel used to estimate transmission map. Transmission is related with minimum channel image W(x) and difference between R, G, and B channel D(x). It is very difficult to estimate these coefficients. Thus creates a linear model in order to learn coefficients using bright pixel intensity as atmospheric light. After that getting values of coefficients transmission can be estimated. Then scene radiance recovered by using atmospheric scattering model.

Abhiraha et.al [7] proposed a method based on color attenuation prior model. According to this model atmospheric luminance is considered as a constant and relatively high intensity in intrinsic luminance. The brightness and saturation of pixels may vary due to the change in the haze concentration. Scene depth restoration can be done with the help of linear model. The concentration of haze can be calculated by taking difference between brightness and saturation of the haze. To find out accurate depth map information, generate a random depth map of same size. Accurate depth map can be estimated by using the informations like depth, brightness and saturation. Finally, scene radiance can be recovered with the help of depth map and atmospheric scattering model.

Ju et.al [8] proposed a fast haze removal method based on the haze thickness in which input image is partitioned into several scenes. Scene wise rough scene luminance map can be calculated by averaging and erosion operations. The scene luminance and scene transmission is estimated for limited number of scenes. Thus transmission estimation process becomes simpler. Refining of scene transmission map and scene luminance map eliminate the negative effects caused by scene wise operation. It preserves the essential depth structure.

Segmenting input image into several non-overlapping patches helps to avoid texture brightness and texture blurring. The averaging operation reduces scene segmentation errors. Scene reflectance can be derived from scene transmission map and scene luminance map. Scene restoration is achieved by scene reflectance. Gayathri et.al [9] proposed a novel method in which atmospheric scattering model relates luminance and located distance of an object. According to this model atmosphere is considered as homogeneous and atmospheric scattering coefficient as a constant. Estimation of depth helps to effectively refine transmission. It is done with the help of median filter which preserves edge information and avoids block of artifacts generation. Depth and transmission map estimation is based on Dark Channel Prior. Visibility restoration technique is used to improve color map of an images. It helps to enhance brightness of the images. Local extrema based method is used to restore images. This method consists of three steps:

1) Sky light estimation: Atmospheric light estimated through dark channel prior.

2) Coarse estimation of atmospheric veil: Applying minimum operation among three color channels and estimating a rough transmission of atmospheric veil.

3).Image restoration by local extrema: An edge preserving smoothing approach based on local extrema is applied for refinement.

Yuan et.al [11] proposed a strategy for dehazing which segments sky regions from input image by utilizing mean shift algorithm and quad tree splitting [17]. Mean shift based sky region segmentation segments the input image into several sections. It is based on the luminance of each pixel. Quad tree based feature pixel splitting method works on the observation that a sky region is smooth having high brightness and located on the top of the image. Initially dividing input image as four regions. Usually sky areas are situated on the top of an image. Top left and top right areas are additionally separated into four. In order to estimate the medium transmission of non-sky region DCP is proposed. DCP calculate medium transmission map based on an adaptive patch size. After that a region wised medium transmission are applied for the sky region to estimate medium transmission. It is based on color characteristics of sky region (CCSR). An edge preserving medium guided filter is used to smooth the medium transmission map. Global atmospheric light is assessed with the help of the dark channel. Finally, Image restoration process completed based on region wised medium transmission and atmospheric scattering model.

Sreekutty et.al [12] proposed a simple and powerful color attenuation prior model. According to this model scene depth is positively correlated with the haze concentration. Concentration of haze increases along with the changes of scene depth. Scene depth is made by utilizing a prior linear model. A linear model uses the difference between brightness and saturation of the haze in order to find the concentration of the haze. Training data is required to get linear co-efficients. Training data includes of hazy image and its depth map. It is very difficult to obtain accurate depth map. So a random depth map, with same size is generated for each haze free image. In order to estimate atmospheric light, selected highest intensity pixels from hazy images are among these bright pixel intensity is taken as atmospheric light. Transmission map can be calculated by using information from depth map. Thus scene radiance can effectively recover by taking parameters of depth map and transmission map.

Wang et.al [13] proposed a linear transformation based de- hazing method. This method is mainly divided into three steps: Atmospheric light estimation, Transmission map estimation and Image restoration. Atmospheric light estimation is performed through gray scale transformation. In order to acquire sky region quad tree subdivision is adopted. Atmospheric light can be evaluated by taking average gray of sky region. Medium transmission map can be estimated by utilized this assumption. Since at least one reflection coefficient of the color component is very small in color images. The numerator and denominator were calculated for

three color channels with minimum filter. Gaussian filtering is used to filter rough transmission map. It is exceptionally powerful in edge preserving. Finally image restoration can be obtained using atmospheric scattering model.

Bi et.al [14] proposes a single image haze removal algorithm which accurately estimate transmission based on atmospheric scattering model. Haze free or haze image can reflect the brightness information and light reflection property of the scene, based on this brightness map is created. In the case of haze image the brightness map have high value in a large sky area with dense haze and bright color objects. Highest intensity pixel in the input image is chosen for the estimation of atmospheric light. Rough brightness map can be obtained from atmospheric light intensity. An edge preserving guided filter is employed to get a refined transmission map which avoids the halo effects. Finally image contrast can be improved by an unsharp masking algorithm.

Liu et.al [15] proposed a novel and effective haze removal method. Hazy image can be formed as a combination of scene radiance and global atmospheric light. White balance is processed on the input hazy image instead of estimating the global atmospheric light directly. Thus global atmospheric light considered as pure white. Generally atmospheric veil is taken as constant in a local patch to estimate atmospheric veil. DCP works on the assumption that most local non sky regions in the haze free images have some low intensity pixels. Refinement is required to improve the accuracy of initial atmospheric veil. An energy optimization is used for the refinement and it will generate a structure aware atmospheric veil. Haze free image can be restored by inverting atmospheric scattering model. In addition to the brightness adjustment an adaptive exposure scaling is also adopted.

TABLE I. COMPARISION TABLE

Author	Reference	Advantage	Disadvantage
Jian	[6]	Faster processing speed.	Used for real time system.
Abiraha	[7]	High efficiency, Outstanding dehazing effect.	Depth map is inaccurate in some cases.
Ju	[8]	Effective in solving problems like uneven illuminance, over enhancement and over saturation.	Scene segmentation creates errors.
Gayathri	[9]	Accurate image restoration for color and details.	Time consuming.
Yuan	[11]	Very less noise.	Suffers color distortion.
Sreekutty	[12]	Transmission map estimation is accurate.	Supervised learning model is need to access the depth information.
Wang	[13]	Good dehazing effect.	Overall visual effect may be darker.
Bi	[14]	Less computational complexity.	Cannot be used for real time requirement.
Liu	[15]	Produce high visibility.	Higher computational efficiency.

III. C ONCLUSION

For many reasons dehazing has become an important and urgent research problem in the field of computer vision. So haze removal techniques become more useful for many computer vision applications. Most of the existing methods eliminated many issues related to dehazing. Several dehazing algorithms are existing, but no technique is accurate for determine kind of circumstances. The survey has shown that the presented methods possess faster processing speed and can be applied for real time requirement. Most of the methods are effective in solving problems like uneven luminance, over enhancement and over saturation. In some methods overall visual effect may be darker. To overcome this problem color compensation methods like tone mapping, gray compensation method can be used to adjust the brightness according to the actual situation.

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