A SURVEY OF HAZE REMOVAL TECHNIQUES FOR IMAGE PROCESSING

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ABSTRACT

One of the key issues within the space of image process is that the restoration of the images those are corrupted as a result of numerous degradations. Images of outside scenes taken during a bad weather conditions comprises of atmospherical degradation. As the light travels from the scene point towards observer, it is scattered and absorbed by particles in space like haze and fog. Attributable to the presence of those atmospherical particles there's a resultant degradation within the color and distinction within the captured image within the bad weather conditions. This causes difficulty in detecting the objects of images. During current days attributable to the recent development of the machine vision area, it's doable to enhance the outside hazy pictures and take away the haze from the images. Images captured in foggy climatic conditions usually has poor visibility, this can produce plenty of impacts on the outside computer vision systems, like video police work, intelligent transportation help system, and remote sensing house cameras then on. In this review paper, we've given and compared a study of varied fog/haze removal algorithms/techniques for image processing. The clear objective of this paper is to explore the pitfalls of the techniques utilized in the revolutionary era of image processing applications.

Keyword *: - Dehazing, image defogging, image restoration, airlight, attenuation, scene radiance.*

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1. INTRODUCTION

Images taken in bad weather conditions, which contains haze or fog are degraded. In these conditions, when we take a images employing a camera then the sunshine gets scattered before reaching the camera as a result of some impurities within the atmosphere. As a result of this, automatic observation system, out of doors recognition system and intelligent facility area unit badly affected. Attenuation and airlight are the two main things which causes scattering of light. By utilization of haze removal algorithms, we are able to enhance the steadiness and lustiness of the sensory system. Removal of haze could be a tough thing as a result of fog depends upon the unknown scene depth data. Fog impact is outlined as event of distance between camera and object. There are two haze removal categories: image improvement and image restoration. Image enhancement does not embrace the rationale why fog degrades image quality. Contrast of image gets enhanced in this method but information in an image can get lost. Several vision algorithms has a low- contrast scene radiance. A single input haze removal is considered as a difficult task; hence many researchers are using multiple images to remove a haze.

2. THEORETICAL BACKGROUND

This section describes the different atmospheric model those describe the degradation level

2.1 Atmosphere and the vision.

Basically, all the research in vision is based on the very fact that observer is in the clear medium(air). It has been assumed that light rays mirrored by scene objects reach the observer with no attenuation or alteration. With this supposition, the brightness of a pixel of image depends entirely on the brightness of one single point in the scene.

Existing vision sensors and algorithms are created solely to perform on clear days. A good vision system but should consider the entire cases of atmospheric condition which can contain haze, fog, rain, snow.

Haze is ingrained of aerosol that could be a spreaded little particles of gas. Haze includes a various set of sources together with volcanic ashes, foliage exudations, combustion merchandise, and ocean salt. The particles made by these sources respond quickly to changes in humidity. These particles can act as a centre of water droplets in a high humid weather. Air molecules are larger than haze particles. Fog droplets are smaller than haze particles. A gray hue caused by haze particles causes poor visibility.

2.2 Atmospheric scattering Model

Atmospheric scattering characteristics are illustrated by attenuation and airlight.

2.2.1 Attenuation Model

How light gets attenuated while travelling from scene point to the camera, is described by the attenuation model. Owing to the atmospherical scattering, some of the light is detached from the incident ray. The unscattered light reaches a camera. This light is called direct transmission. The attenuated irradiance received at the observer is given by

$$E_{dt}(d, \lambda) = E_{\infty}(\lambda)\, r(\lambda)\, e^{-\beta(\lambda)d} / d^2 \quad (1)$$

d= depth of the scene point from the observer
λ= wavelength
$\beta(\lambda)$= scattering coefficient of the atmosphere
$E\infty$= horizon brightness
r= function describes the reflectance properties

2.2.1 Airlight Model

This model illustrates about the atmosphere's acting as a supply to replicate the environmental illuminations towards the observer. The mirrored light travels the whole path length d, the gap from the scene purpose to the observer or the camera.

The irradiance due to the airlight is given by

$$E_a(d, \lambda) = E_{\infty}(\lambda)(1- e^{-\beta(\lambda)d}) \quad (2)$$

The total irradiance received is the sum of irradiance due to the direct attenuation and the airlight.

$$E(d, \lambda)= E_{dt}(d, \lambda) + E_a(d, \lambda) \quad (3)$$

2.3 Haze formation Model

In a machine vision the most widely used model for the formation of hazy pictures is given as:

$$I(x) = t(x)*J(x) + (1 - t(x))*A \quad (4)$$

Where x indicates the position of the picture element, I is that the determined hazy image, J is that the scene radiance which is haze free image, A is the atmospheric, t is the medium of transmission describing the portion of the light that's not scattered and reaches the camera. The transmission features a scalar worth ranges from zero to one for every picture element and therefore the worth indicates the depth of the data of the scene objects directly. For the same medium the transmission will be expressed as t(x) = e-β(λ)d where β is that the scattering constant of the medium. Scene radiance is attenuated exponentially with the scene depth. Primarily the image received by the observer is that the combination of the attenuated scene radiance with haze layer, haze color is represented by atmospheric light. The ultimate goal of the haze removal is to get the scene radiance J, A and t from the determined hazy image.

Haze removal is used to get the haze free image from the observed hazy image. But while doing the dehazing for a image, the transmission co-efficient t is unknown, the airlight A, the scene radiance J (or the haze free image) is unknown. Hence if the airlight and also the transmission co-efficient t is recognized then the scene radiance will simply be recovered.

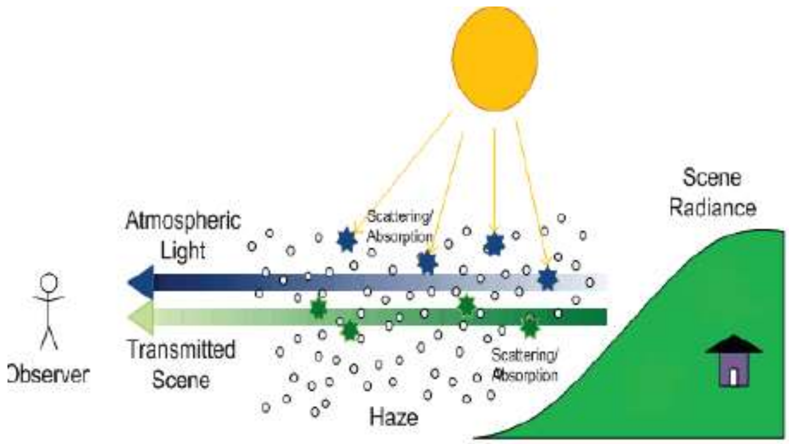

Fig 1: Haze Model [18]

3. Dehazing Methods

Under the inclemency conditions the atmosphere contains the fog and haze particles so the colour and contrast of image is corrupted. The degradation level will increase with the space from the camera to the scene. This is called scene depth. Depth needs to be estimated to get haze free image. Previously multiple images needs to be used to get the depth but in recent days only single image needs to be used.

Schechner and et al [1] paper is predicated on the very fact that sometimes airlight scattered by the atmospherical particles is partly polarized. Haze cannot be removed by using polarization filter alone. This paper illustrates the image formation method considering the polarization impact of atmospherical scattering and inverting the method is needed to urge a haze free image. Scene radiance within the absence of the haze and also the airlight are the two unknows of image. As the airlight is sometimes partly polarized, two independat images are required to recover these two unknowns. This proposed paper describes an method that doesn't want the climate to vary and it will be applied instantly. The polarizer is used to get or capture the image. The advantage of this method is, polarizer filter improves the contrast of image. The orientation of filter also plays role in contrast enhancement.

Narasimhan and et al [2] presented a physics-based model that describes the appearances of scenes in uniform bad weather conditions. Changes in intensities of scene points under different weather conditions provide simple constraints to detect depth discontinuities in the scene and also to compute scene structure. Then through a fast algorithm scene contrast is restored. This methodology takes consideration of images taken in different weather conditions.

Fattal and et al [3] introduced a replacement approach for single image dehazing that made a haze free image from the input hazy image. Image formation model is created by Fattal. Surface shading and also the transmission perform is related to this model. The model constructed by Fattal was refined. Haze formation mode can be portrayed as

$$I(x)= t(x)*J(x) + (1 - t(x))*A \quad (5)$$

Where x indicates the position of the picture element, I is the determined hazy image, J is that the scene radiance which is haze free image that's to be rehabilitated, A is that the global atmospheric light, t is that the medium of transmission describing the portion of the light that's not scattered and reaches the camera. Fattal sorted picture elements for same surface and has the same surface reflectance and same constant surface albedo. Surface shading and therefore the transmission is determined by Independent Component Analysis. Surface shading and therefore the scene transmission are unrelated, this is used is to decide the airlight-albedo uncertainty.

Tan [4] proposes a single image dehazing approach. This method is based on two basic observations: first,images with enhanced visibility have more contrast than images plagued by bad weather; second, airlight whose variation mainly depends on the distance of objects to the viewer, tends to be smooth. Then a cost function in the framework of Markov random fields is optimized to restore the contrast of hazy image.

He and et al [5] dark channel prior relies on the previous assumption is largely used for single image dehazing method. This dark channel previous prior is based on the principle that the data point approach of the out of doors haze free image. Some pixels, in most of the native regions that don't cowl the sky have very low intensity in a minimum of one color (RGB) channel. These pixels with low intensity are called dark pixels. These pixels are used to derive the transmission. These pixels are present due to airlight. Combination of haze imaging model and determined transmission map is used to get haze free image. Soft matting technique is used for this purpose. A high quality haze free image can be derived by this method.

Gibson and et al.[6] proposes a method, which uses DCP to dehaze image or video. This method operates at a faster speed and can avoid halo effects by using the median operation. In this method compression is done after dehazing to low bitrates (using compression) in the transmission pipeline.

Schaul and et al. [7] technique supported the actual fact that in out of doors photography, the distant object are blurred Its color and visibility degrades due to presence of haze. Within the projected paper the fundamental plan is employed to merge the visible and a near-infrared image of the given input image to get a dehazed image. Multi-resolution method using the edge preserving filter is used to reduce the artifacts. These artifacts were produced during the dehazing process The projected approach describes that from the given input hazy image each visible and near-infrared pictures are extracted. Edge-preserving multi-resolution decomposition on the basis of Weighted Least sq. (WLS) improvement framework are applied to each visible and near-infrared images. Picture element level merging criteria are accustomed to enhance the regions those contain the haze.

Tarel and et al [8] proposes a a novel algorithm and variants for visibility restoration from a single image. The main advantage of the proposed algorithm is its speed: its complexity is a linear function of the number of image pixels only. The proposed method can handle color and grey level images both. Atmospheric veil inference, image restoration and smoothing, tone mapping are the key parameters of algorithm.

Wang and et al [9] has explored that haze removal from the image rely upon the unknown depth info. This algorithmic rule is predicated on the principle of atmospheric scattering model. In this methodology on designated region a dark channel prior is applied to urge a completely unique estimation of atmospheric light. The proposed model is predicated upon some observation on haze free out of doors image. There's a minimum of one color channel has terribly low intensity at some pixels, in non sky patches. This low intensity pixels are caused due to shadows, and dark objects ,etc.

Ancuti and et al [10] delineate that the haze is that physical occurrence which degrades the visibility of the out of doors images taken beneath bad atmospheric conditions. A single image dehazing has been explained in this paper. White balance and contrast enhancing is used to derive fusion strategy and it is derived from single input hazy image. The fusion based technique determine sensory activity based qualities: weight maps for every of the picture element of image. Luminance, chromaticity and saliency are determined to minimize the artifacts. The artifacts produced during the weight maps. The multiscale method utilises the laplacian pyramid combination with Gaussian pyramids of normalized weights. This method tries to minimize artifacts. Artifacts are tried to minimize on pixel base, rather than patch base.

Xie and et al [11] methodology describes the dehazing method using dark channel prior and multi-scale retinex. Dark channel prior and multi-scale retinex are used to dehaze the image. This proposed method gets provides the quick acquisition of transmission map of the scene, which iis automated. The planned methodology is predicated on the principle of implementing the multi scale retinex algorithmic rule on the luminance component in YCbCr space to urge the pseudo transmission map .The obtained transmission map is incredibly a lot of almost like the transmission map obtained by victimization the dark channel previous by He et.al[10]. Combination of the haze imaging model and also the dark channel prior is used to get a prime quality haze free image. The input hazy image has been born-again from RGB color space to YCbCr space then by using the multiscale retinex algorithmic rule, on the brightness level element of the remodeled image with some adjustment to urge the transmission map. Then combining each the haze image model and also the retinex algorithmic rule a much better haze free image is recovered.

Shuai and et al [12] mentioned issues concerning the dark channel prior of color distortion drawback for a few light white bright space in image. Median filtering supported the dark channel was proposed in this algorithm. Wiener filtering is applied after getting more accurate media function. By this fog restoration drawback is regenerate into an improvement drawback and by minimizing mean sq. error a clearer, finally fog free image is obtained. This method provides a clearer and better dehazed image than the dark channel prior method.

Yeh and et al [13] has proposed a pixel-based dark channel prior. Fog density is estimated to get haze free image in this method. First estimation of light is done. In this methodology, first pixel based dark channel is done then fog density is estimated to get the haze free image. Transmission maps are refined by using the trilateral filter.

Tripathi and et al [14] has described that fog formation is as a result of airlight and attenuation. Airlight will increase the achromatic color and attenuation will increase the contrast within the scene. thus a way is planned that use trilateral filter to recover scene contrast and for the estimation of light. The planned methodology doesn't rely upon the density of fog and doesn't need user interference. It will handle each color and grey pictures. Contrast of fog removed images is post processed by histogram stretching. During this generated airlight map doesn't have an effect on the edges and perform smoothing over the object region. Because the methodology is freelance of density of fog in image thus it conjointly performs higher for image taken in significant fog thus, it is wide used as a pre process step for numerous machine vision algorithms that use feature info like object detection, recognition, pursuit and segmentation.

Hitam and et al [15] has given a replacement technique known as Mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color models that specifically developed for beneath water image improvement. The technique operates CLAHE on RGB and HSV color models and each results area unit combined along Euclidean norm.

Meng and et al [20] method is regularization technique to get rid of hazes from one input image. This technique advantages a lot of from a look on the inherent boundary constraint on the transmission function. This constraint is employed together with a weighted L1−norm primarily based contextual regularization is employed to model the optimization problem to estimate the unknown scene transmission. This proposed technique needs solely many general assumptions and might restore a high-quality haze-free image with trustworthy colours and fine image details.

4. CONCLUSIONS

Haze removal techniques can be devided into multiple image dehazing and a single image dehazing methods. In earlier times, multiple images were used for image dehazing, recent vision algorithms are designed to perform on a single image dehazing. Most of the single image dehazing approaches are based on atmospheric scattering model. In this paper, we’ve got delineate that the haze layer is present within the captured input image depends on the scene depth and its variant in nature. During this paper we've addressed various strategies, and conclude that depth information of hazy image is important. Haze information is often calculable from the captured hazy pictures and once estimating the depth map and exploitation the image formation model a stronger and improved haze free image are often recovered.

5. REFERENCES

[1] Y.Y.Schechner, S.G.Narasimhan, S.K.Nayar, “Instant Dehazing of Images Using Polarization,” Proc. IEEE Conf.Computer Vision and Pattern Recognition, vol. 1, pp.325-332, 2001.

[2] S. G. Narasimhan and S. K. Nayar. "Contrast restoration of weather degraded images," *IEEE Trans. Pattern Analysis and Machine Intelligence (TPAMI)*, vol. 25, no.6, pp. 713-724, 2003.

[3] R. Fattal, “Single Image Dehazing,” ACM Trans. Graph., SIGGRAPH, vol. 27, no. 3, p. 72, 2008.

[4] R. T. Tan, “Visibility in bad weather from a single image,” *in Proc. IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2008, pp. 1-8.

[5] K. He, J. Sun, and X. Tang, “Single image haze removal using dark channel prior,” IEEE Conference on Computer Vision and Pattern Recognition, pp. 1957–1963, 2009.

[6] K. B. Gibson, D. T. Vo and T. Q. Nguyen, “An investigation of dehazing effectss on image and video coding”, *IEEE Trans. Image Processing* (*TIP*), vol. 12, no. 2, 2012.

[7] Schaul, Lex, Clément Fredembach, and Sabine Susstrunk. "Color image dehazing using the near-infrared." International Conference onImage Processing (ICIP), 2009 16th IEEE International Conference on. IEEE, 2009.

[8] J. P. Tarel, and H. Nicolas, “Fast visibility restoration from a single color or gray level image,” *in Proc. IEEE Conference on Computer Vision (ICCV)*, 2009, pp. 2201-2208.

[9] Wang, Yan, and Bo Wu Improved single image dehazing using dark channel prior IEEE International Conference on Intelligent Computing and Intelligent Systems. Vol.2. IEEE.2010

[10] Ancuti, Codruta Orniana, Cosmin Ancuti, Philippe Bekaert. "Effective single image dehazing by fusion." Image Processing (ICIP), 2010 17th IEEE International Conference on. IEEE, 2010.

[11] Xie, Bin, Fan Guo, and Zixing Cai. "Improved single image dehazing using dark channel prior and multi-scale Retinex."Intelligent System Design and Engineering Application (ISDEA), 2010 International Conference Vol. 1.IEEE, 2010

[12] Shuai, Yanjuan, Rui Liu, and Wenzhang He (2012) Image Haze Removal of Wiener Filtering Based on Dark Channel Prior Eighth International Conference on Computational Intelligence and Security, IEEE.

[13] Yeh, Chia-Hung, et al.(2012)Efficient image/video dehazing through haze density analysis based on pixel-based dark channel prior International Conference on Information Security and Intelligence Control. IEEE.

[14] Tripathi, A. K., and S. Mukhopadhyay (2012) Single image fog removal using trilateral filter IEEE International Conference on Signal Processing, Computing and Control. IEEE.

[15] Hitam, M. S., W. N. J. H. W. Yussof, E. A. Awalludin, and Z. Bachok 2013 Mixture contrast limited adaptive histogram equalization for underwater image enhancement International Conference on Computer Applications Technology, pp. 1-5. IEEE.

[16] A Review on Various Haze Removal Techniques for Image by Manpreet Kaur Sagguand Satbir Singh International Journal of Current Engineering and Technology Vol.5, No.3 (June2015)

[17] A Survey on Image Dehazing Methods by Khitish Kumar Gadnayak Pankajini Panda, Niranjan Panda International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 10, October – 2013.

[18] A Survey on Image Dehazing Methods by Khitish Kumar Gadnayak Pankajini Panda, Niranjan Panda International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 10, October – 2013.

[19] J. Yu, C. Xiao, and D. Li, “Physics-based fast single image fog removal,”in *Proc. IEEE 10th Int. Conf. Signal Process. (ICSP)*, Oct. 2010.

[20] G. F. Meng, Y. Wang, J. Duan, S. Xiang, and C. Pan, “Efficient imagedehazing with boundary constraint and contextual regularization,” in *Proc. IEEE Int. Conf. Comput. Vis. (ICCV)*, Dec. 2013..