

Fog-Removal in Single Image using Various Methods: A Survey

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Abstract—The images which are taken in foggy weather/bad weather are not expressed clearly therefore they are not very comprehensible. The images that are taken in that environment will be reduced in quality to a great degree, the reason is that because of the scattering of light in the atmosphere will reduce the clarity and visibility of a single image. Because of fog, the images are in low contrast whereas in case the haze in the atmosphere will affect the clearness and precision of the image. The pictures taken in this condition will not only affect the visibility but also complicate the post-processing of the image required for the implementation of numerous computer vision algorithms. Hence it is important to eliminate fog from the image So, firstly density of fog is estimated and based on that, image defogging can be done.

Index Terms— Defogging, single image, image enhancement, image restoration, DCP, surrogate model, FADE.

I. INTRODUCTION

Droplets of water in the air cause mist. Whereas Haze occurs because there are molecules or dewdrops in the air. Mist also called as the fog is the result of the dispersion of light, as well as absorption of light by microscopic water droplets which are found in the surroundings and lowers the clarity and correct shades of photos. Hence, removing the fog from images is necessary to obtain a clear picture. There are two kinds of attenuation that fog produces [12] in the pictures they are (i) Air-light (ii) Direct attenuation. A light ray from the picture is attenuated by dispersing by atmospheric particles, known as attenuation, which makes the difference between the scene less apparent. Because dust particles are present, sunlight is dispersed toward the camera, resulting in color changes known as air light. The image's intensity values are degraded and affected which in turn reduces the contrast of an image in direct attenuation. Air-light results in color degradation in the foggy image [3]. There are many applications where fog in images can be a disadvantage, including object recognition, surveillance of video, navigation purposes, and remote sensing. The particles absorb the light and disperse it, as a result of their absorption and scattering, images captured outside will become a blur. Therefore, image defogging algorithms related to physical atmospheric scattering models [1] have been proposed to help with eliminating the fog effect. There are a number of techniques that are presented to determine the fog density, which shows the extent of visibility decreasing pictures obscured by fog. In reference to undertaking the high effective defogging, it is critical to employ objective criteria instead of subjective judgment to measure the fog density. As a result of the presence of air pollutants, the reflected light from Before reaching the camera, the surface is scattered through the atmosphere. This is due to aerosols that deviate the light from its original path.

In long distance foggy scenes, the picture is significantly influenced by the technique in which colors of surface become faint. Such degraded photographs offer the poor visibility of the content in image.

The defogging methods which are widely used are offered as a result of the physical air scattering model provided by [1]

$$I_o(X) = J_o(X)T_o(X) + A_o(1 - T_o(X)) \quad (1)$$

Equation (1) $I_o(X)$ represent foggy picture, $J_o(X)$ represents the fog less picture which is required picture, $T_o(X)$ transmission of picture, A_o represents the ambient light and X is the coordinates of pixel.

The amount of light that makes it to the camera is denoted by

$$T_o(X) = e^{-D_o(x)} \quad (2)$$

$$D_o(x) = \beta d_o(x) \quad (3)$$

$d_o(x)$ represents the distance between observer and point of view, also called as the atmosphere's scattering coefficient, $D_o(x)$ is the point of view that is optical depth, indicating that with increasing optical depth, transmission attenuates dramatically.

The fog removal in single image is very challenging task since the estimation of fog density should be calculated. There are two types of picture defogging methods [8]: first, these approaches/techniques are on the depth map, apply a trainable machine learning model of a mist scene in photos, and these methods get better the fog image patches by gaining insight from hazy picture samples that are comparable.

Second type of techniques use basic and effective picture enhancing techniques which do not utilizes the machine learning techniques. The traditional works uses the picture enhancement methods such as white balance correction, median based filter, equalization of histogram and smoothing the edge.

A. MOTIVATION

The primary motive of this paper is to give a view of different image defogging techniques. More and more vehicles are automated these days thanks to machine learning and other sources. We need a technique to remove the haze or fog from the image so the machine can able to process the image to identify the object clearly. Thus, it helps in many video surveillance methods.

II. LITERATURE SURVEY

[1] During foggy circumstances, a camera placed on a speeding object is used to measure visibility distances. In this work, the researchers aimed towards detecting fog during the day and determining its distances of visibility. The International Commission on Illumination claims, a black object of a certain region of space can be perceived with a contrasting of less than 5% at a distance greater than this (CIE). The approach is based on an atmospheric physical diffusion model, which allows determining the "meteorological visibility distance" by merely checking to make sure the road and the sky are present in each image using a region expansion technique. In spite of this, the technique can't be used in the dark and is ineffective when there is a lot of road masking.

[2] In this paper a simple and powerful algorithm is studied called DCP (dark channel prior) is a technique that is based on data from outside images. The fog imaging model is combined to make it simpler and more effective. The normalized haze imaging equation is given by [1] equation 1 and estimated transmission is measured by

$$t_o(X) = 1 - \min_{Y \in \Omega(X)} \left(\min_{A_o} \frac{I_o(x)}{A_o} \right) \quad (4)$$

In equation (4) $I_o(x)$ is the foggy picture. Once the ambient light is estimated by [9] Tan's method, where the dazzling pixels on the screen foggy image are reviewed as fog-opaque, the brightness of the scene is found by

$$J_o(x) = \frac{I_o(x) - A_o}{\max(T_o(X), t_o)} + A_o \quad (5)$$

[3] To reduce the drawbacks of dark channel prior, as an example color deformation in beaming regions like the airspace & sea space, an enhanced algorithm relies on no-reference forecasting of cognitive density fog model, Fog Conscious Intensity Evaluator (FADE), has been used to obtain a high accurate estimate of atmosphere light A and intermediate imparting. Filtering, specifically Fast directed filtering, is also employed to refine the intermediate transmission in this paper. As a result, the outcome of this demonstrates as there are no major color deformation issues in the restored image's airspace.

[4] The transparency of a foggy contrast enhancement is investigated using fog removal techniques on outdoor photos. Dark channel prioritization algorithm [1] is utilized in the paper to estimate transmission using various filters. Different filters are utilized, such as guided filters, mean filters, and gaussian filters, and the results reveal that the effects of the various bilateral filters on image visibility enhancement vary.

[5] The color space is utilized in this research, and it is assumed that the clean and fog-less picture has potency value near to nil in at least anyone of the color channels. Although the dark channel previous method restores the

majority of the color related data, but it is not passed in boosting the image contrast. This problem is solved by employing a enhancement method based on fuzzy logic that consists of six steps: weather and sunlight evaluation, transmission measurement, refinement of transmission map, recovery of the scene, fuzzy contrast improvement, and post-processing operations on the image. The picture is then transformed into a fuzzy domain, and many important procedures on the pictures are performed to adequately recreate the contrast.

[6] The picture restoration is done in this research by calculating the approximate depth map using a Framework for defogging that is both simple and strong by considering the fog thickness in the local pixels.

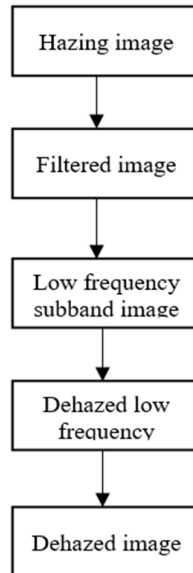


Figure 1: Algorithm flowchart

The transmission of the point-specific dark channel is computed using the depth map information. To improve the restoration, a post-processing method based on histogram normalization approach is utilized in this research. [7] The dark channel prior and directed filtration are used in tandem in the dual tree complex wavelet transform space in this paper to illustrate a defogging technique.

The approach depicted in fig 1 uses directed filtering to smooth the hazy image before decomposing it into low and high frequency sub band elements using the dual-tree discrete wavelet transform.

After that, the DCP model is utilized to handle the image's less frequency sub band and the dehazed picture is obtained utilizing the complicated wavelet transform with inverse dual tree.

Because the complicated wavelet transform with inverse dual tree provides transmission advantages like deterioration, improved positioning precision, computational advantage, guided filtering, it can broaden the field of haze removal transmittance applications and raise the algorithm's complexity, which greatly decrease or reduce the optimization time, The algorithm explained in this paper can help to boost the image's contrast and clarity.

[8] The fog density is evaluated first, and after that, the fog is eliminated from the foggy image, resulting in the defogging process. This work presents a surrogate model for the optical thickness in order to appropriately find the fog density. To begin, fog-relevant properties such as grey image, local contrasting, immersion value, chroma and chroma variance, colourfulness, and sharpness are investigated, and a color space based on colour, brightness & significance color space that is more closely associated with fog density perception is proposed.

A) METHODOLOGY

There are three types of fog elimination approaches (i) filtration techniques, (ii) color rectification related techniques, and (iii) techniques that are related to learning. There are two types of learning-based approaches: (a) easy- learning related methods and (b) deep-learning related methods. Filter-based techniques, color correction related approaches, and easy learning related techniques are all examples of restoration-based procedures.

Filter-based techniques:- For transmission map refinement, this category includes methods using filters. In Fig. 2, refinement of the map of transmission is the rear move in estimating Information about the depth Map. It is the oldest among three categories.

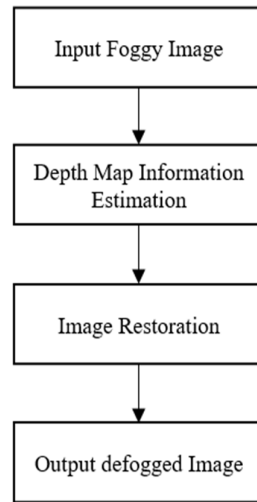


Figure 2: Framework for removing fog for restoration-based techniques

Techniques related to color correcting:- This category includes methods for defogging hazy images that use hue correction. Colour casts in fog pictures may affect little or every channels of the picture. Therefore, there is a requirement to apply colour modification to these pictures to achieve effective defogging

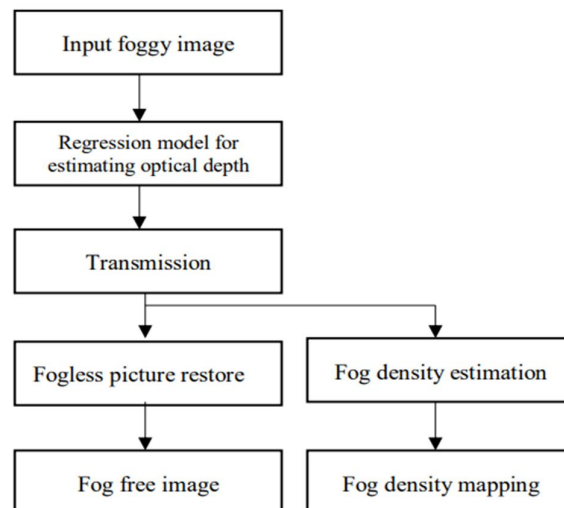


Figure 3: Estimation of density of fog and remove the fog from image

Methods based on Learning:- The model has been programmed to build transformation matrix for the provided input and result in learning-based methods. The mapping function's parameters must be approximated in required to train the model. Therefore, Ground-truth photos with no fog and their foggy counterparts (ground-truth + fog) must be used. Such pairings can be made accurately by involving technology fog to a ground truth image. Deep-learning methods play a significant role in object recognition and classification.

A trained model (PRG) for depth is developed using this surrogate-related method that includes mist-related parameters namely chroma, brightness value, and dark channel chosen based on sensitivity examination. Fog thickness estimation and visual defogging are done out using the precise model for optical depth obtained.

II. RESULTS AND DISCUSSION



Figure 2: Tested results for image defogging techniques

The fig 2 gives the results tested for existing different defogging methods in the image defogging field and table gives the comparison on the existing image defogging techniques.

TABLE I: COMPARISON TABLE ON EXISTING IMAGE DEFOGGING TECHNIQUES

Sl no	Authors	Paper Name	Method Used	Remarks
1	HN, Tarel JP, Lavenant J, Aubert D[1]	Automatic fog detection and estimation of visibility distance through use of an onboard camera. Machine Vision and Applications.	Physical diffusion model of the atmosphere	The technique can't be used in the dark and is ineffective when there is a lot of road masking.
2	Kaiming He, Jian Sun, and Xiaou Tang, FellowS [2]	Single Image Haze Removal Using Dark Channel Prior.	Dark channel Prior with haze imaging model to estimate the thickness of Haze.	Fail to recover the true scene radiance of the distant objects and they remain bluish.

3	Rujun Li, Kintak U [3]	Haze Density Estimation and Dark Channel Prior Based Image Defogging.	Fog Aware Density Evaluator (FADE)- Fog density Model	There is no serious color distortion problem in the sky region of the restored image.
4	Neha, Rajesh kumar Aggarwal [4]	Study of Single Image Fog Removal Techniques in low Visibility foggy Images.	DCP with different filters	Bilateral filter perform better than the others.
5	Subhadeep koley, Ahana sadhu, Hiranmoy Roy[5]	Single Image visibility restoration using Dark channel prior and Fuzzy logic	Dark channel prior and Fuzzy-contrast enhancement	Different parameter values are exploited and optimized to make the algorithm more efficient
6	Tkokul, Anparasy[6]	Single Image defogging using depth estimation and scene-specific dark channel prior.	Depth map estimation, histogram based post processing technique	Recovering performance is improved.
7	Yue dongqiao, huang yuanyuan, Tang haozhe, Huang xi, Qin zhi[7]	Single Image Dehazing jointly utilizing dark channel prior and guided filtering in dual-tree complex wavelet domain.	Dark channel prior, Guided filtering, Dual tree complex wavelet transform.	Algorithm only dehazed the low-frequency sub-band components
8	Yutong Jiang, Changming Sun, Yu Zhao and Li Yang[9]	Fog density Estimation and Image defogging based on Surrogate modeling for Optical depth	Surrogate regression model	Some scene points are deviated from the learned model.

III. CONCLUSIONS

Here In this paper, we study recent advances in fog removal techniques. Initially, the new fog removal methods are classified. From each method, we study the most prominent techniques/methods in detail. The goal of separate fog algorithms is to improve image visual quality which are affected by foggy conditions. Every fog removal techniques has advantages and disadvantages. Therefore, there is still need for advancement across all methods. If we consider the filters techniques, the techniques could become quick without the block artifacts and halo effect (without degrading the restored image). When it comes to colour correction, the procedures should work for cloudy photos that have or don't have colour casting. Taking out the fog Learning-based methods are also expected to work well for genuine photos while using a CPU or a low-end GPU.

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