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A Survey Paper On Single Image Dehazing

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Abstract**—** Images taken in foggy weather condition often suffer from poor visibility and clarity. Images of the outdoor scene which are captured under bad weather conditions contain atmospheric degradation such as haze, fog, smoke caused by the particles present in the atmosphere resulting in the absorption and scattering of the light, which travels from the scene point of the observer. Due to the presence of the various atmospheric particles (like fog, mist, smoke, water-droplets etc.) there is a resultant decay in the color and contrast of the images captured under the bad weather conditions. Such images also exhibit some losses in their quality which are dependent on the distance. Sometimes it may also causes difficulty in detecting the objects in the hazy images or scene. So, if the depth and the atmospheric condition are known, we can enhance the images by compensating the effect of the fog. This paper describes the various haze removal techniques to remove the haze from the captured hazy images and to recover a better and improved quality haze free images.

Keywords- *Image Dehazing; Haze Formation Model; Fattal Method; Polarization Filtering; Dark channel prior; Fusion Dehazing*.

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I. INTRODUCTION

Most outdoor visual systems such as video surveillance, target tracking, remote sensing and navigation control and vehicle autonomous driving and others are highly vulnerable to harsh environment, especially because of fog and haze. Images of outdoor scene can be significantly degraded due to the bad weather condition such as fog and haze. Thus it lead to the atmospheric scattering of tiny water droplets and atmospheric aerosol on the scene point, causing image fuzzy, bad visibility, and seriously affecting the performance of an outdoor system. This happens because of the presence of numerous atmospheric particles which absorbs and scatters light. Such degraded images lose all its contrast and become dim especially in the distant regions and get blurred with their surroundings area. In order to make the system robust and reliable in bad weather conditions, it is necessary to dehaze that degraded image.

In long distance photography or foggy scenes, this process has a substantial effect on the image in which contrasts are reduced and surface colors become faint. Such degraded images, photographs lack visual vividness and appeal and moreover, they offer a bad visibility of the contents of the scene. This may also be the case for satellite imaging which is used for various purposes like web mapping, land-use planning and environmental studies etc.

In this process light which should have to travel in straight lines is scattered and replaced by the previously scattered light called the airlight. The main objective here is to enhance the images which are taken under poor visibility and even restore the clear-day visibility of that scene. There are many circumstances for which accurate haze removal algorithms are needed. The major goal of the haze removal algorithms is to enhance and recover the detail of the scene from the haze image.

In this paper we explore several ways to reduce the haze from the images that are shot either in foggy weather conditions or any other obstacles in the air which destroys the clarity of image. This problem mostly occurs in the case of larger distant images and especially in the case of aerial imagery. The main principle aim here is to find various ways to separate the haze content from the actual image content and then subtract that haze part in order to end up with a clear picture. One way to find the haze content is by using a polarization filter in front of a camera and alters the orientation of it by different angles and gather all those images. This method is very precise in finding and removing the haze which makes it possible to get a much clearer image at the end.

The scene depth information of the degraded image is also an important clue for the haze removal. Various method extract depth information from multiple images and extra information. For instance, binary scattering model is used, in order to extract scene information from color images under different weather conditions.

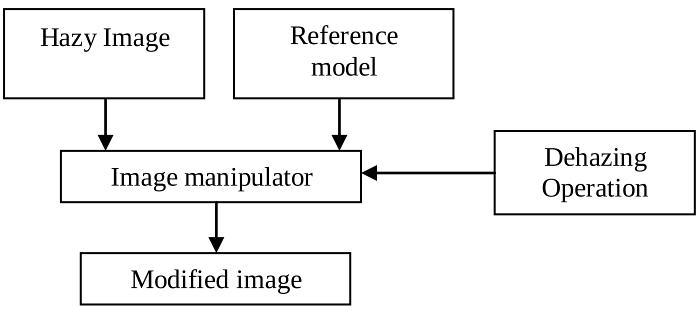

Fig-1 Block diagram of Image dehazing.

II. HAZE FORMATION MODEL

Under bad weather such as fog, haze, mist or smog, the contrast and the color of the images are drastically reduced. In computer vision, the equation below is usually used to describe the formation of foggy or hazy images [1].

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

Where

$I(x)$ indicate the observed hazy image.

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J(x) is the scene radiance which is the reconstructed haze free image.
A is the airlight
t(x) is the transmission function.
x indicate the position of the pixel.
The *t(x)* is the known portion of the light which does not scattered and reached the camera. It is also the portion of the light which survives and reaches the camera. The transmission has a scalar value ranges from 0 to 1 for each pixel and the value indicate the depth of the information of the scene objects directly. For a uniform medium the transmission can be expressed as:-

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

where β is the scattering coefficient of the medium.
d(x) is the scene depth.
It indicates that the scene radiance is attenuated exponentially with the scene depth.

III. DEHAZING TECHNIQUES

The quality of the image taken under bad visibility is always degraded by the presence of the fog, haze, smog, mist. Since the atmosphere was affected, the contrast of the image is greatly reduced. Dehazing is the process of removing the haze from a captured image. Haze removal from a single image of a weather-degraded scene remains a challenging task, because the haze is dependent on the unknown depth information. During the past few years many researchers have proposed different methods in order to solve the problem of how to obtain a high quality haze-free image. Various dehazing methods are as follows:-

A. Fattal method

Rannan Fattal considers that the shading and transmission signals are un-correlated [1]. Based on this assumption, the airlight-albedo ambiguity can also be resolved. He used Independent Component Analysis (ICA) to estimate the transmission, and then deduct the color of the whole image by Markov Random Field (MRF). The method performs quite well for haze, but declines with scenes involving fog. This method is physically valid and capable to restore the contrasts of complex hazy scene. Moreover, since this method does not assume the haze layer to be smooth, the discontinuities in the scene depth or medium thickness are permitted. This assumption is sometime violated when the shading and transmission signals are correlated and deliver a poor dehazing result.

Fattal grouped the pixels belonging to the same surface having the same reflectance and the same constant surface albedo. He proposed Independent Component Analysis method to determine the surface shading and the transmission function. The basic key idea here is to resolve the airlight- albedo ambiguity and assuming that the surface shading and the scene transmission are uncorrelated.

Fig-2 (a) (b)

In the above fig-2, (a) represents the input image to the fatal method and (b) represents the output after applying the fatal method.

B. Polarization filtering

Schechner in [2] paper proposed that usually airlight scattered by the atmospheric particles is partially polarized. Polarization filter alone can't remove the haze effect. This paper describes the image formation process considering the polarization effect of the atmospheric scattering and inverting it in order to get a haze free image. Generally the image is basically composed of the two unknown components, first one is the scene radiance in the absence of the haze and the other one is airlight. To recover these two unknown components two independent images are required. Usually the airlight is partially polarized. This paper also describes an approach that does not need the weather conditions to change and it can be applied instantly. The images taken through a polarizer uses polarization filtering. The polarization filtering and the orientation of the polarization filter improve the contrast of the single input image.

In order to solve the problem of the haziness, polarization filtering is used to determine the haze content of the image and then this haze contents are eliminated from the image to get the clear image.

Fig:-3 (a) (b)

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In the above fig-3, (a) represents the unpolarized image whereas (b) represents the polarized image.

C. Dark Channel Prior

Kaiming in [3] proposed that dark channel prior is based on the prior assumption which is basically used for the single image dehazing process. This dark channel prior method is based on the statistics approach of the outdoor haze free images. It has been observed that in most of the regions which do not covered the sky; at that region some pixels are having very low value in at least one color (RGB) of the channel. These pixels are known as dark pixels. In hazy images the intensity of the dark pixels in the colored channel is basically contributed by the airlight. These dark pixels are used to estimate the haze transmission.

Thus finally after estimating the transmission map for each pixel, combining it with the haze imaging model and soft matting technique [4] to recover a high quality haze free image. The proposed method consists of several different phases such as, image segmentation, estimation of atmospheric light and cost function for the estimation of the transmission map.

Then refinement of the transmission using soft matting is being done and finally recovering the scene radiance. In this method first of all the input image is segmented in to different regions using mean shift region segmentation algorithm.

Then by applying the dark channel prior method proposed by the He et al [3] over the segmented image in order to estimate the atmospheric light. After that using the proposed algorithm [5] and estimating the cost of the transmission map. The transmission map is refined by applying the soft matting [4]. And finally the desired haze free image is recovered by recovering the scene radiance using the dark channel prior [3].

(a)

(b)

(c)

Fig-4 Haze removal using dark channel prior.

In the above fig-4, (a) represents the input hazy image, (b) represents the output image after applying dark channel prior method and (c) represents the recovered depth map.

D. Dehazing by Fusion

Schaul in [6] focused on the fact that in outdoor photography, the distance object are appeared blurred and loses its color and visibility due to the degradation level affected by the atmospheric haze. In this paper the key idea is used to the fusion of the visible and near infrared image of the given input image to obtain a dehazed image and it also describes the multi-resolution approach using the edge preserving filter to minimize the artifact those are produced during the dehazing process. The proposed approach describes that from given input hazy image both visible and near-infrared images are extracted. By applying an edge preserving multi-resolution decomposition based on the Weighted Least Square (WLS) optimization framework as described by Farbman et al.[7] to both visible and near infrared images. Pixel level fusions criteria are used to maximize the contrast to improve the regions those contain the haze.

(a)

(b)

(c)

Fig-5 Dehazing using the near-infrared.

IV. CONCLUSION

These paper gives a brief review on various dehazing techniques. in this paper that the haze layer present in the images captured in the bad weather conditions is dependent on the depth of the scene and sometimes it is variant in nature. and also in this paper we have discussed several methods in which the haze can be estimated from the captured hazy images and after estimating the depth map and various dehazing methods, a better and improved haze free images can be recovered. in some cases filters are also used in order to get a good quality haze free images without estimating the depth.

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