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Fog Removal Techniques using Image Processing

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Abstract: Fog is a big reason of road accidents, flight delays, late arrival of trains, etc. This project aims to resolve the sight problem faced by car/train/other automobile drivers when driving in cold weather condition/rain. Fog has affected many human activities, such as shipping, travel and warfare. Fog reduces contrast level of the image that affects the visual quality of image. Fog reduces visibility to less than 1 kilometer. For improving the visibility level of an image and reducing fog, various image enhancement methods are used. For improving the visibility level four major steps are used. First step is acquisition process of foggy images. Second is estimation process. Third is enhancement process (improve visibility level, reduce fog). Last process is restoration process (restore enhanced image). The main aim is to review image enhancement and restoration methods for improving the quality and visibility level of an image which provide clear image in bad weather condition.

Keywords: Image defogging, Computational photography, Image restoration, Image enhancement.

I. INTRODUCTION

The images of outdoor scenes are usually degraded by the turbid medium (e.g., particles and water droplets) in the atmosphere. Haze, fog and smoke are such phenomena due to atmospheric absorption and scattering [7]. This occurrence influences the normal work of automatic (mechanized) monitoring system, outdoor recognition system and smart transportation system [8]. Light from the atmosphere and light reflected from an object are scattered by the water droplets, resulting the visibility of the scene to be degraded. The two fundamental phenomena that are consequence of scattering are 'attenuation' and 'airlight'[1]. By the usage of effective haze or fog removal of image, we can improve the stability and robustness of the visual system. Haze removal is a difficult task because fog depends on the unknown scene depth map information. Fog effect is the result of distance between camera and object. Hence removal of fog requires the estimation of airlight map or depth map. The current haze removal method can be divided into two categories: (a) image enhancement and (b) image restoration. Enhancing the images acquired in poor weather conditions is called de-weathering and has been a very critical issue in applications such as aerial photography, driving assistance and visual surveillance [11]. Restoration of images is important in several outdoor applications such as remote sensing, intelligent vehicles, etc. [2].

II. LITERATURE SURVEY

This section covers the literature survey from the study of various research papers. The literature survey describes various methods for improving foggy images. A brief description of various processes given by different authors is given below:

A.K. Tripathi et al (2012) proposed a novel fog removal algorithm. Proposed algorithm uses anisotropic diffusion for refining airlight map from dark channel prior. Proposed algorithm requires pre- and post-processing steps. Histogram equalisation and histogram stretching are used as a pre-processing and post-processing, respectively. Proposed algorithm can be applied for colour as well as grey foggy images. For colour images, proposed algorithm uses RGB (red, blue and green) or HSI (hue, saturation and intensity) colour model. Proposed algorithm has few parameters and constants. The parameters are data driven and constants remain same irrespective of the image under restoration. Hence proposed algorithm does not require user intervention. Results show that proposed algorithm performs well in comparison with other existing algorithms. Even in case of heavy fog, proposed algorithm performs well, as algorithm is independent of the density of fog present in image. In order to evaluate the performance, contrast gain, percentage of number of saturated pixels and computation time are calculated. Results confirm that proposed algorithm enhances images with a significant margin, that is, high contrast gain and very low saturated pixels. Compared with other algorithms, proposed algorithm using HSI model takes very less computation time, which paves the way for real-time implementation. Proposed algorithm can be used as a pre-processing for various algorithms such as object detection, tracking and segmentation.

Cosmin Ancuti et al (2013) introduced an alternative single-image based strategy that is able to accurately dehaze images using only the original degraded information. However, in contrast to existing techniques, they built their approach on a fusion strategy. They are the first to demonstrate the utility and effectiveness of a fusion-based technique for dehazing on a single degraded image. The main concept behind their fusion based technique is that they derive two input images from the original input with the aim of recovering the visibility for each region of the scene in at least one of them. Additionally, the fusion enhancement technique estimates for each pixel the desirable perceptual based qualities (called weight maps) that controls the contribution of each input to the final result. In order to derive the images that fulfill the visibility assumptions required for the fusion process, they analyze the optical model for this type of degradation. Their technique has several advantages over previous single image dehazing methods. First, their approach performs an effective per-pixel computation, different from the majority of the previous methods. A proper per-pixel strategy reduces the amount of artifacts, since patch based methods have some limitations due to the assumption of constant airlight in every patch. In general, the assumptions made by patch-based techniques do not hold, and therefore additional post processing steps are required. Secondly, since they do not estimate the depth (transmission) map, the complexity of their approach is lower than most of the previous strategies. Finally, their technique performs faster which makes it suitable for real-time applications.

Ding Meng et al (2015) presented the haze removal which actually considers de-hazing and defogging. From the optics perspective, single-image haze removal is a method that is used to remove atmospheric scattering from a single image containing haze or fog. The algorithm estimates the transmission map by computing the mean vector L2-norm of the sample window to replace two minimization filters and reduces computational complexity. Meanwhile, considering the lack of a color ellipsoid model with depth discontinuity, the proposed algorithm uses a guidance filter to optimize and refine the transmission map **t**. This paper also improves clear image restoration to directly obtain a clear image with adequate brightness.When compared with the transmission maps estimated using the dark channel method, the proposed method does not require two minimum filters. The improved image restoration process directly recovers a clear image with enough brightness, therefore the author do not need to increase the exposure of the recovered image for display.

Ekta Chauhan et al (2016) presented a novel algorithm for fog or haze removal purpose with combination of edge enhancement method, color enhancement method, adjustable Wiener filter and also estimates the haze-factor from single image through using an adjustable empirical function without manual input constraint for efficient outcomes. Based on the analysis of atmospheric scattering models and statistics of vrious outdoor images, for foggy images, the author discover that the value highest and lowest in color channels tends to be the atmospheric light value.

Fan-Chieh Cheng et al (2015) proposed a linear time airlight estimation algorithm based on color analysis. In general, airlight estimation can be performed by manual and automatic methods. The manual method directly defines image regions affected by airlight, but it is inapplicable for realistic application due to frequent interruption. In contrast, the automatic methods are more convenient. Compared to the previous methods that only focus on luminance estimation, the proposed method estimates the color probability in YcbCr space to select candidates of the representative fog pixels for airlight computation. According to qualitative evaluation by visual inspection, quantitative assessment using FSIM metric, Big-O notation, and execution time estimation, they have verified that their proposed method is more effective than the compared methods and has very low computation cost.

Jyoti Sahu et al (2012) proposed an effective fog-free methodology to remove fog from input image. In this method, firstly, the original image is converted from RGB to YCbCr. Secondly, compute the intensity component of the YCbCr image and key observation of the all pixels of the image. Most local patches in fog-free outdoor images contain some pixels which have very low intensities in at least one color channel. Using this methodology with the fog image, the author can directly estimate the local white balancing of the image, global white balancing of the image, median of the image and mean of the image. After getting all above details, the author applied an original image and finally show the fog free image. The proposed algorithm of the article is an efficient and reliable choice for fog removing from the color image and also useful in hue preserving contrast enhancement of colored images.

Kaiming He et al (2011) proposed a novel prior-dark channel prior-for single image haze removal. The dark channel prior is based on the statistics of outdoor haze-free images. They found that, in most of the local regions which do not cover the sky, some pixels (called dark pixels) very often have very low intensity in at least one color (RGB) channel.

In hazy images, the intensity of these dark pixels in that channel is mainly contributed by the airlight. Therefore, these dark pixels can directly provide an accurate estimation of the haze transmission. Combining a haze imaging model and a soft matting interpolation method, we can recover a high-quality haze free image and produce a good depth map. Their approach is physically valid and is able to handle distant objects in heavily hazy images. They do not rely on significant variance of transmission or surface shading.

Qingsong Zhu et al (2015) proposed a novel color attenuation prior for single image dehazing. This simple and powerful prior can help to create a linear model for the scene depth of the hazy image. By learning the parameters of the linear model with a supervised learning method, the bridge between the hazy image and its corresponding depth map is built effectively. With the recovered depth information, they can easily remove the haze from a single hazy image. The efficiency of this dehazing method is dramatically high and the dehazing effectiveness is also superior to that of prevailing dehazing algorithms.

By creating a linear model for the scene depth of the hazy image with this simple but powerful prior and learning the parameters of the model using a supervised learning method, the depth information can be well recovered. By means of the depth map obtained by the proposed method, the scene radiance of the hazy image can be recovered easily.

T.L. Economopoulos et al (2010) introduces a novel method for contrast enhancement, based on the theory of the Partitioned Iterated Function System (PIFS). The aim of a PIFS is to find parts of an umage that are similar to other, properly transformed (scaled-down, flipped, rotated, sheared, etc.)pa rts. The objective of the proposed algorithm is to provide strong contrast enhancement, by increasing the mean contrast measurement of the enhanced image, without affecting the information stored in the original image. The performance of the proposed algorithm has been compared against three other methods for image enhancement: the Linear and Cubic Unsharp Masking techniques, the Contrast Limited Adaptive Histogram Equalization approach and the Local Range Modification method. Qualitative and quantitative comparative results show advantageous performance of the proposed, PIFS-based, contrast enhancement algorithm. After quantitative and qualitative analysis of the proposed algorithm, it was shown that it is able to increase the mean contrast of the enhanced image, thus achieving quite high mean contrast gain over the original image. The introduced PIFS algorithm proved to be quite tolerant in the presence of noise, as it was capable to increase the contrast gain of the test images without amplifying the noise, in terms of PSNR. The PIFS model has been extensively used in image compression, due to the scalability it provides.

Yuan-Kai Wang et al (2014) proposed a multiscale depth fusion (MDF) method with local Markov regularization to recover fog images with only one single foggy image as input. The MDF method employs the Markov random field (MRF) to blend multi-level details of chromaticity priors. A stochastic relation between fog priors and depth map is first linearly modeled, and a new random field called inhomogeneous Laplacian-Markov random field (ILMRF) with the energy model incorporating the fog priors is proposed for the estimation of depth map. The ILMRF adaptively fuses the fog priors from multiscale filtering results according to local regularization. The defog method first estimates the depth map and airlight, then applies the atmospheric scattering model to restore scene reflectance. The estimation of depth map is an iterated algorithm consisting of the alternate optimization of the two variables in the ATL potential: a line field variable for adaptive control and a base potential variable to regularize smoothness. Maximum likelihood scheme for the initialization and parameter estimation of the algorithm is applied to improve the efficiency of the iteration. The estimation of airlight utilizes the fused depth map with a smooth constraint to find fog-opaque regions that help compute more accurate atmospheric luminance.

III. CONCLUSION

Fog due to dust, smoke and other dry particles reduces visibility for distant regions by causing a distinctive gray hue in the captured images. Fog or Haze elimination is difficult because the fog is dependent on the indefinite depth information. Haze removal methods have become more useful for many computer vision applications. All the dehazing methods useful for surveillance, intelligent vehicles, for remote sensing and under water imaging, etc. Fog removal algorithms are used to improve the visual quality of an image, which is affected by light scattering through haze particles. This paper presents various simple and faster defogging methods used in the field of image processing techniques, through which fog can be estimated from the captured foggy images.

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