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Review paper

A Survey on Different Image Dehazing Techniques.

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Abstract: The following paper is composed of a literature survey conducted on various techniques used for haze removal. A number of issues in regards to multiple computer vision and graphics applications are caused due to Haze since it lessens the visibility of the scene. Haze formation is mainly due to two central phenomena that are attenuation and air light. Contrast is reduced by attenuation whereas the white in the scene is enhanced by air light. Color and contrast of the scene can be recovered with the help of haze removal techniques. The various applications that utilize these methods are object detection, outdoor surveillance, consumer electronics etc. The paper aims to discover different techniques that are utilized in order to remove haze from digital images in an efficient manner in order to acquire an image free from haze. The restrictions of the present methods being used are mentioned at the end of the paper.

Keywords: Air light, CLAHE, Dark channel prior, Independent component analysis, Polarization.

1. Introduction

The water droplets, as well as various other particles present in the atmosphere oftentimes, degrade many images containing outdoor scenes. The atmospheric absorption and scattering caused atmospheric phenomena such as haze, fog and smoke **[7].** The regular functioning of outdoor recognition system, an automatic monitoring system, and smart transportation system are affected by such occurrence the **[1].** Water droplets tend to scatter light from both the atmosphere and from objects as well thus degrading the visibility of the scene. 'Attenuation' and 'air-light' are caused due to this scattering of light **[2].** The distance of the scene points from the camera determine the amount of scattering. Methods of removing haze are distinguished into two types: (a) image enhancement and (b) image restoration. De-weathering is the method that enhances the images which are taken in bad weather conditions. Bad weather conditions are considered an important issue in regards to various applications such as driving assistance, aerial photography visual surveillance **[3].**

Restoration of the image plays an important role in a number of outdoor applications such as smart vehicles, remote sensing, etc. **[4].** The quality of output image can be improved in a significant manner by eliminating haze from the input hazy image. Therefore, a number of methods have been adopted to improve the quality of the output image. The fig.1 below shows the flow diagram of the existing methods

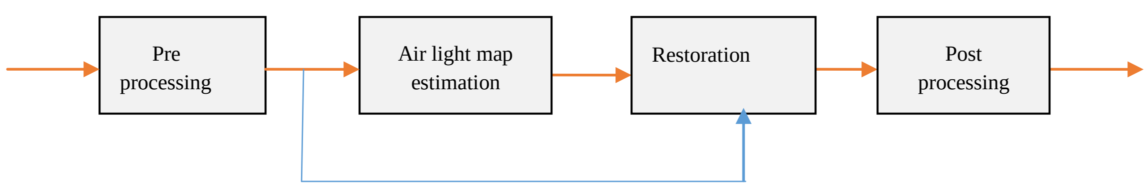

Figure-1: Flow diagram of existing methods

A foggy image can be represented as

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

Where I is intensity value of the pixel, J is the original scene radiance, A is global air light and t is the medium of transmission. This defines the portion of light that does not scatter and is able to reach the camera. Air light A describes the portion of light that is scattered from scene or object. To estimate original scene radiance it is necessary to estimate A in any fog removal method. The dark channel shown before is founded on the succeeding surveillance on haze-free outdoor images: amongst the various non-sky patches, mostly a single color channel is present having low intensity at some pixels. The least amount of intensity in these patches should be of a low value. Thus this is computed in the present work as (2)

$$J^d = min_{y\in\Omega(x)}\left(\left(1 - \sigma_{rgb}\right) * \mu_{c\epsilon\{r,g,b\}}\left(J^c(y)\right)\right) \quad (2)$$

In which $J^c$is a color channel of J, μ is a mean and is σ_{rgb} standard deviation of RGB intensity values and $\Omega(x)$ is a local patch centered at x.There are three main features which cause low intensities in the dark channel. The first feature is shadows; shadows created by large buildings, cars, along with the shadows inside the windows in cityscape images, shadows created by rocks, leaves, trees in landscape images. The second feature is colorful or bright surfaces and objects such as grass, trees, plants that are green in color or flowers that are either red or yellow along with the blue color of water surfaces, especially those objects that lack color in any color channel, thus resulting in lesser values in the dark channel. The third feature is those dark surfaces or objects such as stones, tree trunks, and dark trees **[5].** The dark channels of the images come out extremely dark since the images taken in a natural outdoor setting are full of color and shadows. The dark channel helps to estimate the air-light. Any pixel possessing the highest level of intensity can be thought of as air light.

2. Different Approaches

Several researchers used different traditional techniques of image processing to remove haze from the image so as to enhance the hazy images' quality.

Sahu et al. **[6]** proposed an efficient fog-free procedure to eliminate fog from the input image. The original image is first transformed from RGB to $YCbCr$ in this procedure. Then the intensity component of all the present pixels of the $YCbCr$ image is computed. Pixels having low intensities of a minimum single color channel can be found in mostly a number of local patches in images taken in an outside setting free from fog. Based on the above principle local white balance and global white balance of the image are estimated. A fog-free output image is obtained after finalizing all the above-mentioned details. This method is found to be highly effective and dependable for eliminating fog from the color image but it does not use any physical model of degradation and in many cases produce over-saturated results.

Fattal et al. **[8]** proposed the latest technique to estimate the transmission map of the specified hazy input image. Through this estimation, the scene visibility is increased and the scene contrasts free of haze are also recovered by eliminating the scattered light. This specific work utilizes Independent component analysis. A refined image formation model is built in this particular method that is accountable for transmission function as well as surface shading. This method aids in resolving any doubts in the data when it searches for those particular solutions which have shading and transmission functions that are locally statistically uncorrelated. Another method similar to this is utilized in estimating the haze color. A benefit of utilizing this particular method is that it shows an improved enhancement of foggy images as well as provides a dependable estimation of transmission. However, the disadvantage of using this particular method is that the quality of the output for images having high fog density is not good.

Zhang et al and Narasimhan et al. **[9], [10]** recommended a technique using several images captured in different weather conditions. In their approach, by establishing a relation between two images air light and transmission map are calculated. They removed the fog using the physical model by substituting air light and transmission. The drawback of this method is the availability of the same scene under a number of weather conditions.

A method recommended by Schechner, et al**. [11]** is able to overcome degradation effects in underwater vision. This method analyzes the corporeal effects of visibility degradation. The major cause of degradation is due to the partial polarization of the light. So this problem can be solved by the inverting the image formation process by recovering good visibility in images of the scene. The algorithm does not require measurement of any environmental parameters and exploits natural lighting. Also, it is founded on two images clicked through a polarizer at the dissimilar degree of polarization. This method achieved good improvement in scene contrast and color corrections.

Tarel et al. **[12]** proposed an algorithm founded on the filtering approach to be used for visibility restoration from a single image. The algorithm while being founded on linear operations, requires a number of different factors in order to adjust. The major advantage of this method is its speed. Visibility restoration can be easily applied with the aid of this method so that an image can be dehazed in real-time applications. Another latest filter was also recommended which helps to preserve the edges and corners as an alternative option to the median filter. Due to the presence of discontinuities present in the scene depth, the dehazed image obtained by utilizing this method is not of a good quality.

In order to restore the degraded color images, Xu, et al. **[13]** recommended a $CLAHE$-based method. The first step in this technique is to convert the original image to HSI color space from RGB color space because colors are represented by HSI similar to how colors are sensed by the human eye. The second step requires the $CLAHE$ to process the intensity component of the image. The hue and saturation are not changed. The final step requires the conversion of the HIS color space processed image into RGB color space again. The clipped pixels are redistributed in an equal manner to all the gray-level and the biggest value is also established so as to clip the histogram. The noise can also be limited while the contrast of the image is being enhanced.

Arun et al **[14]** recommended a technique to remove fog that can produce relatively more enhanced images and does not require the use of histogram equalization, a pre-processing technique. The DCP principle is used at the beginning of this technique and the High Dynamic Range (HDR) tone mapping is done by utilizing Weighted Least Squares (WLS) to adjust contrast along with visualizing the fine detail inside an image. Color images and one color channel grayscale foggy images can be corrected using this particular algorithm. Clear edges having details, preserved color quality of the image and better contrast can be found in the output fog-free image.

A technique was suggested by He et al**. [7]** which was founded on the dark channel previously for removing haze in single images. The majority of the intensity of the dark pixels in the RGB channel present in hazy images is due to air light. Thus a precise estimate of the haze transmission can be provided by the dark pixels. A high-quality image without haze can be recovered when a soft matting interpolation method is combined with a haze imaging model. Their approach is tangibly able to withstand the presence of objects far away in images with a heavy haze. The main limitation of this method is the computationally expensive soft matting technique which takes more time to process image.

Table 1.Advantages and Disadvantages of existing methods

S.No	Method used	Advantages	Disadvantages
1.	Method based on different weather conditions	Can remove fog in both color images and gray level images.	This method failed because of the unavailability of reference image and also not efficient on dynamic scene.
2.	Method based on polarization	Improvement in scene contrast and correction of color	This method requires expensive equipment and also failed in case of dynamic scenes
3.	CLAHE	Limits noise while enhancing the contrast of image.	This method only improves the visibility but it doesn't provide the vividness and contains halo effects.
4.	Independent component analysis	Provides reliable transmission estimate.	This method gives valid results but failed in case of dense fog.
5.	Dark channel prior with soft matting technique	Can handle distant objects in high density hazy images.	This method uses expensive soft matting technique and takes more processing time.

3. Conclusion

Visibility for regions far away can be reduced by Haze caused by dust, smoke, and other dry particles. Poor visibility conditions can cause Hazy images to suffer from low contrast and resolution. Various image dehazing techniques are discussed in this paper. Every technique has both pros and cons. The existing techniques have neglected the use of the dark channel in the past to reduce the noise and to reduce the computational complexity. To overcome the drawbacks of the present method a new algorithm will be suggested in the coming years. The cross-bilateral filtering will be used as a post-processing step to eliminate the noise from the input and to reduce the computational complexity.

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