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Review on Single Image Fog Removal

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Abstract- In this paper, reported algorithms for fog removal are reviewed. Fog reduces the visibility of scene and thus performance of various computer vision algorithms which use feature information. Formation of the fog is the function of the depth. Estimation of depth information is under constraints problem if single image is available. Hence, removal of fog requires assumptions or prior information. Fog removal algorithms estimate the depth information with various assumptions, which are discussed in details here. Fog removal algorithm has a wide application in tracking and navigation, electronics, and entrainment industries.

Keywords-RGB image, image processing, color model, binary image, 4-connected component.

I. INTRODUCTION

Images of outdoor scenes captured in bad weather suffer from poor contrast. Under bad weather conditions, the light reaching a camera is severely scattered by the atmosphere. So the image is getting highly degraded due to additive light. Additive light are form from scattering of light by fog particles. Additive light is created by mixing the visible light that is emitted from different light source. This additive light is called air light. Air light is not uniformly distributed in the image. Bad weather reduces atmospheric visibility. Poor visibility degrades perceptual image quality and performance of the computer vision algorithms such as surveillance, tracking, and navigation. Thus, it is very essential to make these vision algorithms robust to weather changes. From the atmospheric point of view, weather conditions differ mainly in the types and sizes of the particles present in the space. A great effort has gone into measuring the size of these particles. Based on the type of the visual effects, bad weather conditions are broadly classified into two categories, steady and dynamic. In steady bad weather, constituent droplets are very small and steadily float in the air. Fog, mist, and haze are examples of steady weather. In dynamic bad weather, constituent droplets are 1000 times larger than those of the steady weather. Rain and snow represent dynamic weather conditions.

There have been some notable efforts to restore images degraded by fog. The most common method known to enhance degraded images is histogram equalization. However, even though global histogram equalization is simple and fast, it is not suitable because the fog's effect on an image is a function of the distance between the camera and the object. Another effective method is to restore degraded images is scene depth method but here required two images which are taken under different whether condition for comparing the image quality. When using the wavelet method also required several images to accomplish the enhancement.

Enhancement of image degraded by fog

A. *Problem definition*

Taking an image in foggy weather conditions that images become degraded due to the presence of air light.

B. *Objective*

To detect the air light in each regions of degraded image and restore that image. Removal of fog is important for the tracking and navigation applications, consumer electronics, and entertainment industries. Fog degrades the perceptual image quality, thus the efficacy of computer vision algorithms based on small features or high frequencies. Removal of fog from images as a preprocessing increases the accuracy of these computer vision algorithms. A feature point detector can fail if images have low visibility. If fog is removed and image is enhanced, then feature point detector can work with higher accuracy.

II. What is fog?

The official definition of fog is a visibility of less than 1,000 m. This limit is appropriate for aviation purposes, but for the general public and motorists an upper limit of 200 m is more realistic. Severe disruption to transport occurs when the visibility falls below 50 m. Useful labels for these three categories are aviation fog, thick fog and dense fog.

A. *What causes fog?*

Fog is caused by tiny water droplets suspended in the air. The thickest fogs tend to occur in industrial areas where there are many pollution particles on which water droplets can grow.

B. *Types of fog*

Fogs which are composed entirely or mainly of water droplets are generally classified according to the physical process which produces saturation or near-saturation of the air. The main types of fog are:

1) Radiation Fog: This type of fog forms at night under clear skies with calm winds when heat absorbed by the earth's surface during the day is radiated into space. As the earth's surface continues to cool, provided a deep enough layer of moist air is present near the ground, the humidity will reach 100% and fog will form. Radiation fog varies in depth from 3 feet to about 1,000 feet and is always found at ground level and usually remains stationary. This type of fog can reduce visibility to near zero at times and make driving very hazardous.

Valley fog is a type of radiation fog that is very common in the mountains of eastern Kentucky. When air along ridge tops and the upper slopes of mountains begins to cool after sunset, the air becomes dense and heavy and begins to drain down into the valley floors below. As the air in the valley floor continues to cool due to radiational cooling, the air becomes saturated and fog forms. Valley fog can be very dense at times and make driving very hazardous due to reduced visibility. This type of fog tends to dissipate very quickly once the sun comes up and starts to evaporate the fog layer.

2)Advection Fog: Advection fog often looks like radiation fog and is also the result of condensation. However, the condensation in this case is caused not by a reduction in surface temperature, but rather by the horizontal movement of warm moist air over a cold surface. This means that advection fog can sometimes be distinguished from radiation fog by its horizontal motion along the ground.

Sea fogs are always advection fogs, because the oceans don't radiate heat in the same way as land and so never cool sufficiently to produce radiation fog. Fog forms at sea when warm air associated with a warm current drifts over a cold current and condensation takes place. Sometimes such fogs are drawn inland by low pressure, as often occurs on the Pacific coast of North America.

Advection fog may also form when moist maritime, or ocean, air drifts over a cold inland area. This usually happens at night when the temperature of the land drops due to radiational cooling.

3)Upslope Fog: Upslope fog forms when light winds push moist air up a hillside or mountainside to a level where the air becomes saturated and condensation occurs. This type of fog usually forms a good distance from the peak of the hill or mountain and covers a large area. Upslope fog occurs in all mountain ranges in North America. This usually occurs during the winter months, when cold air behind a cold front drifts westward and encounters the eastward facing slopes of the Rocky Mountains. As the cold, moist air rises up the slopes of the mountains, condensation occurs and extensive areas of fog form on the lower slopes of the mountains. This type of fog forms when the air temperature is well below freezing and is composed entirely of tiny ice crystals that are suspended in the air. Ice fog will only be witnessed in cold Arctic / Polar air. Generally the temperature will be 14 F or colder in order for ice fog to occur.

4)Freezing Fog: Freezing fog occurs when the water droplets that the fog is composed of are "supercooled". Supercooled water droplets remain in the liquid state until they come into contact with a surface upon which they can freeze. As a result, any object the freezing fog comes into contact with will become coated with ice. The same thing happens with freezing rain or drizzle.

5)Evaporation or Mixing Fog: This type of fog forms when sufficient water vapor is added to the air by evaporation and the moist air mixes with cooler, relatively drier air. The two common types are steam fog and frontal fog. Steam fog forms when cold air moves over warm water. When the cool air mixes with the warm moist air over the water, the moist air cools until its humidity reaches 100% and fog forms. This type of fog takes on the appearance of wisps of smoke rising off the surface of the water. The other type of evaporation fog is known as frontal fog. This type of fog forms when warm raindrops evaporate into a cooler drier layer of air near the ground. Once enough rain has evaporated into the layer of cool surface, the humidity of this air reaches 100% and fog forms.

III Literature Survey

Bad weather caused by atmospheric particles, such as fog, haze, etc., May significantly reduces the visibility and distort the colors of the scene. This is due to the following two scattering processes, (i) light reflected from the object surface is attenuated due to scattering by particles, and (ii) some direct light flux is scattered toward the camera. These effects result in the contrast reduction increases with the distance. Under foggy weather conditions, contrast and color of the images are drastically degraded. Clear day images have more contrast than foggy images. The degradation level increases with distance from camera to the object. Enhancement of foggy image is a challenge due to the complexity in recovering luminance and chrominance while maintaining the color fidelity. During enhancement of foggy images, it should be kept in mind that over enhancement leads to saturation of pixel value. Thus, enhancement should be bounded by some constraints to avoid saturation of image and preserve appropriate color fidelity. Initial works in fog removal are based on the contrast enhancement without any knowledge of the fog model. The most commonly used contrast enhancement method is histogram equalization and its variations. Some other image enhancement techniques are also presented by many researchers in order to restore contrast of fog-degraded images. All the techniques proposed, assumes a certain set of attributes of the fog degraded images. Histogram equalization may not improve contrast of the image which lies in right range of histogram. In computer vision, the atmospheric scattering model is usually used to describe the formation of a foggy or hazy image. Almost all established methods are based on this model. Some of them require multiple input images of a scene; e.g., images taken either under different atmospheric conditions or with different degrees of polarization. Another methods attempt to remove the effects of fog from a single image using some form of depth information either from terrain models or user inputs .In practical applications, it is difficult to achieve these conditions. So such approaches are restricted. The very latest defogging methods are able to defog single images by making various assumptions about the depth or colors in the scene.

A. CONTRAST ENHANCEMENT BASED ALGORITHM TO IMPROVE VISIBILIT OF COLORED FOGGY IMAGES

Images taken under foggy weather conditions suffer from degradation due to severe contrast loss and also due to loss in color characteristics. The degree of degradation increases exponentially with the distance of scene points from the sensor. Foggy conditions drop atmospheric visibility and brings whitening effect on the images causing poor contrast. Hence basic challenge is to nullify the whitening effect thereby improving the contrast of the degraded image. Manoj Alwani and Anil Kumar Tiwaria [1] present a contrast enhancement algorithm for degraded color images. To restore both contrast and color, here propose four steps. The RGB component of the input image is first converted into HIS space to get brightness component. Because of scene depth varies differently over whole image. The global enhancement method does not reflect depth change. So to take care of local scene depth changes, Process the image on a block by block basis, assuming that the pixels in the block are now of same seen depth. Then enhance the block according to pixel intensities in it. Basically this mean that if the given image has many objects with varying seen depth, global enhancement techniques are expected to do average kind of enhancement of various object. On the other hand, processing on a block-by- block basis will enhance the object effectively.

B. CONTRAST RESTORATION OF WEATHER DEGRADED IMAGES

Most outdoor vision applications such as surveillance, terrain classification, and autonomous navigation require robust detection of image features. Under bad weather conditions, however, the contrast and color of images are drastically altered or degraded. Hence, it is imperative to remove weather effects from images in order to make vision systems more reliable. Unfortunately, the effects of bad weather increase exponentially with the distances of scene points from the sensor. As a result, conventional space invariant filtering techniques fail to adequately remove weather effects from images. Here described a method to restore scene contrast given a depth segmentation of the scene. This method is simple and effective for scenes where depth changes are abrupt. However, it is hard to define good depth segmentation when scene depths change gradually. Here present a method to restore contrast of an arbitrary scene using scaled depths of scene points.

S. G. Narasimhan and S. K. Nayar, [2] proposed a physics-based model that describes the appearances of scenes in bad weather conditions. The air light and the attenuated light are calculated. Here describe a simple method to restore scene contrast from one bad weather image using depth segmentation of the scène. Here consider depth segmentation as the extraction of depth regions in the scene. The brightness at any pixel recorded by a monochrome camera is given.This procedure is repeated independently for each point in the scène. Then a total brightness variation is calculated. Simple image processing techniques such as contrast stretching can be effective for scenes that are at the same depth from the sensor. Here using this contrast stretching technique to restore the degraded image.

C. *CORRECTION OF SIMPLE CONTRAST LOSS IN COLOR IMAGES*

Contrast enhancement methods fall into two groups. They are non-model-based andmodel-based. In non-model-based methods analyze and process the image based solely on the information from the image. The most commonly

used non-model-based methods are histogram equalization and its variations. For color images, histogram equalization can be applied to R, G, and B color channels separately but this leads to undesirable change in hue. Better results are obtained by first converting the image to the Hue, Saturation, Intensity color space and then applying histogram equalization to the Intensity component only.
J. P. Oakley and H. Bu [4] proposed a method for determination of airlight level in digital images. The method involves the minimization of a scalar global cost function and no region segmentation is required. Once the airlight level has been obtained, simple contrast loss is easily corrected. The accuracy of the method under ideal conditions has been confirmed using Monte Carlo simulation with a synthetic image model. Useful levels of performance are also achieved when the synthetic image model is generalized to include noise and other variations in statistical properties. The accuracy of the airlight estimate is insensitive to the scale and contrast of the image fluctuation and the level of variation in image brightness. The synthetic image fluctuation for these studies is generated using the Gaussian distribution. However, useful levels of performance are achieved even when the fluctuation is generated using the Cauchy distribution. Since the Cauchy and Gaussian distributions are very different, so the method is very robust. The method is applicable to both black and white images and color images. It is interesting to consider other types of image that could be processed. Near- IR images generated using active illumination should have a similar structure to visible light images and so the algorithm described here could be applied. Images generated in the mid and far IR bands by passive emission have a statistical structure that is quite different. Since the thermal emission depends on absolute temperature, the images are formed over a relatively small relative temperature variation. The contrast in dark parts of the image can be expected to be roughly the same as in bright parts of the image an important difference from visible images. Thus, the algorithm may not give good results in this case.

D. *ENHANCEMENT OF IMAGE DEGRADED BY FOG*

Under bad weather conditions, the light reaching a camera is severely scattered by the atmosphere. So the image is getting highly degraded due to additive light. Additive light are form from scattering of light by fog particles. Additive light is created by mixing the visible light that is emitted from different light source. This additive light is called air light. Air light is not uniformly distributed in the image. It is known that under fog weather conditions, the contrast and color characters of the images are drastically degraded. Clear day images have more contrast than foggy images. Hence, a fog removal algorithm should enhance the scene contrast. Enhancement of foggy image is a challenge due to the complexity in recovering luminance and chrominance while maintaining the color fidelity. During enhancement of foggy images, it should be kept in mind that over enhancement leads to saturation of pixel value. Thus, enhancement should be bounded by some constraints to avoid saturation of image and preserve appropriate color fidelity. It is noted that effect of fog is the function of the distance between the camera and the scene. If input is only a single foggy image, then estimation of the depth information is under constrained. Generally, estimation of depth requires two images. Therefore, many methods have been proposed which use multiple images. But these methods cannot be applied on simple uncalibrated single camera system. There are many algorithms which remove fog using single image. To refine the estimation of depth information, these algorithms use some assumptions or prior knowledge. Removal of fog requires the estimation of image depth information. This depth information can be derived in terms of airlight map. Airlight map is created by linear regression using least squares. The method of least squares is a standard approach to the approximate solution of over determined systems, i.e., sets of equations in which there are more equations than unknowns. Least square means that the overall solution minimizes the sum of the squares of the errors made in the results of every single equation. Linear regression is an approach to modeling the relationship between a scalar dependent variable y and one or more explanatory variables denoted X. The case of one explanatory variable is called simple linear regression. More than one explanatory variable is multiple linear regressions.

IV Proposed Work

In our proposed work, we apply some steps and get fog free image. The steps are following.

Algorithm for my work-

Input: - Get any type of fogy images.

Output: - Find out fog free image with respect to edges.

Step-1

first we calculate gray image (lumance image), chromatic blue and chromatic red image by using equation 1.

$$Y = 0.299R + 0.587G + 0.114B$$
$$Cb = 128 – 0.168736R – 0.331264G + 0.5B$$
$$Cr = 128 + 0.5R – 0.418688G – 0.081312 \quad \text{------------(1)}$$

Step-2

- Enhancement the luminance image.
- Apply filtering.
- Calculate Overall brightness.
- Calculate Binary Image.

Step-3

- Calculate Normalized Binary Image.
- Apply edges enhancement method.
- Calculate edges.

Step-4

- Merge step 2 and step 3 image (above Binary image and enhance image). Again apply color enhancement method.

Step-5

- Apply possible color restoration on step 4 image.

Step-6

- Compare With Input Image regarding edges value.

Step-7

- We get clear fog free image compare to previous work .

V. Conclusion and Future Work

In foggy weather conditions, images become degraded due to the presence of air light. This is generated by scattering of light by fog particles. Here proposed an effective method to correct the degraded image by subtracting the estimated air light map from the degraded image. The air light map is generated using multiple linear regressions, which models the relationship between regional air light and the coordinates of the image pixels. Air light can then be estimated using a cost function that is based on the human visual model, where a human is more insensitive to variations of the luminance in bright regions than in dark regions. For this Objective, the luminance image is employed for air light estimation. The luminance image is generated by an appropriate fusion of the R, G, and B components. First perform the region segmentation of the YCbCr image. Then calculate the amount of airlight in each region. Then create an airlight map. These experiments on real foggy images confirm significant enhancement in image quality over the degraded image.

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