A Survey on Various Haze Removal Techniques and Features in Digital Image Processing

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Abstract— As the digital world is growing with various kind of data like text file, image, video. Out of those image plays an important role in different field such as remote sensing, social media, etc. So maintain the image quality is done by Digital image processing on various issues. This paper give a brief survey of haze removal techniques for various weather condition. As environment condition vary from time to time by the presence of fog, dust, rain. Image analysis features are describe in this paper with there requirements.

Index Terms— Digital Image Processing, Haze, Information Extraction, Fog removal. visibility restoration.

I. INTRODUCTION

Image in open environment or outdoor scenes consist of various noise in form of fog, rain, haze, etc. Due to the presence of these noise overall quality of the image get degrade. As these unwanted particles in the image scattered light from the source to the object. So removal of these unwanted information is highly desired in the image because of its different requirement for analysis. This can be understand by an example that suppose one computer algorithm required image that is free from those unwanted information. So if input in such type of algorithm contain those haze, dust, etc. produce error in the image processing output. So pre-processing of such type of image is highly desired by various users of different fields. One could easily see how a car navigation system that did not take this effect into account could have dangerous consequences. Accordingly, finding effective methods for haze removal is an ongoing area of interest in the image processing and computer vision fields.

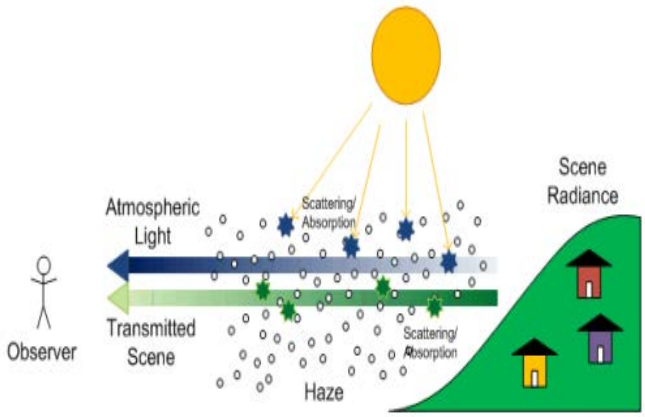

Figure 1: Haze Model

In order to create haze in the image one common formula is

$$I(x) = R(x)*t(x) + a*(1- t(x))$$

where x is a pixel location.

I is the observed image

R is the underlying scene radiance.

a is the atmospheric light (or airlight).

t is the transmission coefficient.

Intuitively, the image received by the observer is the convex combination of an attenuated version of the underlying scene with an additive haze layer, where the atmospheric light represents the color of the haze (figure 1). The ultimate goal of haze removal is to find R, which also requires knowledge of $a\infty$ and t. From this model, it is apparent that haze removal is an under-constrained problem. In a grayscale image, for each pixel there is only 1 constraint but 3 unknowns; for an RGB color image, there are 3 constraints but 7 unknowns (assuming t is the same for each color channel). Essentially, one must resolve the ambiguous question of whether an object's color is a result of it being far away and mixed with haze, or if the object is close to the observer and simply the correct color [1].

II. DIFFERENT TECHNIQUES

Visibility Restoration Technique

As researcher are continuously working in removing haze, fog, mist from the image for further analysis, so various techniques are developed so far. Few of those are explained below:

Dark channel prior: In [2] Dark channel technique is developed in order to calculate the atmospheric light in the image. So it is emerged as a common technique in non sky part of the image because few color channels has very less intensity in the few pixels. Here in dark color channel low intensity is present because of the below three components:

i). Surface Colourful objects such as grass, trees, etc.

ii). Shadow of tree, building, pillers, etc.

iii). Any high intensity object surface such as black stone, trunk, etc.

So most of outdoor image is full of above three points which include colorful object, few shadows and dark channels which fill image with noise. In presence of fog in environment image get brighter then actual image without fog. So it can be conclude that dark channel of the image have high intensity of image in region with higher haze. So in order to find the light intensity an approx value is find by estimating the thickness of the haze. In case of shady channel prior this technique use pre and post processing steps in order to improve results. In post processing stepladder technique use flexible matting or two-sided filtering etc. This can be understand as if J(x) is input image, I(x) is hazy image, t(x) is the transmission of the environment. The reduction of image because of presence of fog can be calculate by:

$$Iatt\ x = J(x)\ *t(x)$$

the effect of fog is Air light effect and it is calculate as:

$$\text{AirLight}(x) = A(1 - t(x))$$

Shady channel for an random image J, uttered as J shady is defined as:

$$Jdark(x) = (min/y \in \Omega\ x)*(\min JC\ Y\ )$$

In this Jc is color image comprising of RGB components, represents a local patch which has its origin at x. The low intensity of dark channels is attributed mainly due to shadows in images, saturated color objects and dark objects in images.

After dark channel prior, we need to estimate transmission t(x) for proceeding further with the solution. Another assumption needed is that let Atmospheric light A is also known. We normalize (4) by dividing both sides by A:

$$Ic/Ac\ (x) = (t(x)*J\ c/Ac\ (x)\ )+ 1\text{-}t(x) \quad (4)$$

Middle: restored haze-free images. Bottom: depth maps.

B. CLAHE

In [3] CLAHE stands for (Contrast limited adaptive histogram equalization). This technique does not require any desired weather data for the dispensation of hazed picture. Firstly, the picture taken by the camera in hazy condition is transformed from RGB (red, green and blue) color space to HSV (hue, saturation and value) color space. The pictures are transformed because the person intelligence colors similarly as HSV represent colors in better way as compare to RGB.

Figure 1: Haze removal results. Top: input haze images.

Secondly strength module is processed by Contrast limited adaptive histogram equalization without effecting hue and saturation matrix of the HSV color modal. This technique use histogram equalization to a background area. The novel

histogram is abrupt and the clipped pixels are rearrange to each gray level. In this each pixel strength is reduced to maxima of user selectable. Finally, the picture operated in HSV color modal is transformed back to RGB color modal.

Figure 2: (a) input image.

Figure 2: (b) output image

C. Wiener filtering

In [4] Wiener filtering is utilize for the counter of problems such as color bend while utilizing shady channel first when the pictures with high white region is operate. While taken shady channel first the value of media function is approx which generate halo distortion in output picture. So,

median filtering is come in existence to calculate the media function, so that edges can be conserved. After making the median function further precise it is shared with wiener filtering so that the picture reinstatement difficulty is altered into optimization problem. So in images having large white region this technique is highly recommended. Overall execution for the algorithms is quite less.

Figure 3: (a) Original foggy image (b) Defogged image (c) Weiner defogged image

D. Bilateral filtering

In [5] Bilateral filtering technique is use for the restoration of hazy image. Here this technique smooth the image without affecting the edge region of the image, this is done by combing the near by values of the pixel. This can be understand as the pixel value is replace by the surround pixel value average. The weight assigned to each neighbor pixel decreases with both the distance in the image plane and the distance on the intensity axis. This filter helps us to get result faster as compare to other. While using bilateral filter we use pre-processing and post processing steps for better results. Histogram equalization is used as pre-processing nd histogram stretching as a post processing. These both steps help to increase the contrast of image before and after usage of bilateral filter.

This algorithm is independent of density of fog so can also be applied to the images taken in dense fog. It does not require user intervention. It has a wide application in tracking and navigation, consumer electronics and entertainment industries.

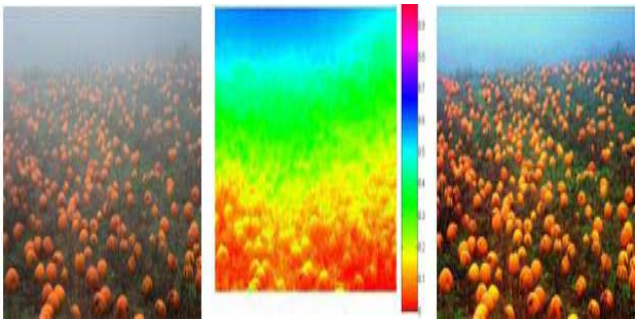

Figure 4: (a) original foggy ‘pumpkins’ image, (b) corresponding air light map using bilateral filter, and (c) Restored image

III. FEATURES FOR HAZE REMOVAL

As Image is collection or sequence of pixel and each pixel is treat as single value which is a kind of cell in a matrices. In order to identify an object in that image some features need to be maintained as different object have different feature to identify them which are explain as follows:

Color feature: Image is a matrix of light intensity values, these intensity values represent different kind of color. so to identify an object colure is an important feature, one important property of this feature is low computation cost .

Different Image files available in different color formats like images have different colure format ranging from RGB which stand for red, green, and blue. This is a three dimensional representation of a single image in which two dimensional matrix represent single color and collection of those matrix tends to third dimension. In order to make intensity calculation for each pixel gray format is use, which is a two dimension values range from 0 to 255. In case of binary format which is a black and white color matrix whose values are only 0 or 1. With the help of this color feature face has been detected efficiently in [8].

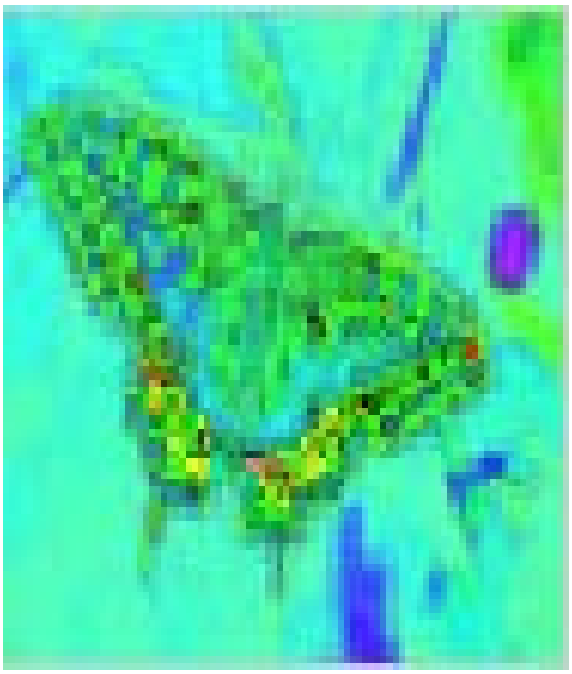

Fig. 3 Represent the HSV (Hue Saturation value) format of an image.

Edge Feature : As image is a collection of intensity values, and with the sudden change in the values of an image one important feature arises as the Edge as shown in figure 4. This feature is use for different type of image object detection such as building on a scene, roads, etc [7]. There are many algorithm has been developed to effectively point

out all the images of the image or frames which are Sobel, perwitt, canny, etc. out of these algorithms canny edge detection is one of the best algorithm to find all possible boundaries of an images.

Fig. 4 Represent Edge feature of an image.

Texture Feature : Texture is a degree of intensity difference of a surface which enumerates properties such as regularity and smoothness [6]. Compared to color space model, texture requires a processing step. The texture features on the basis of color are less sensitive to illumination changes as same as to edge features.

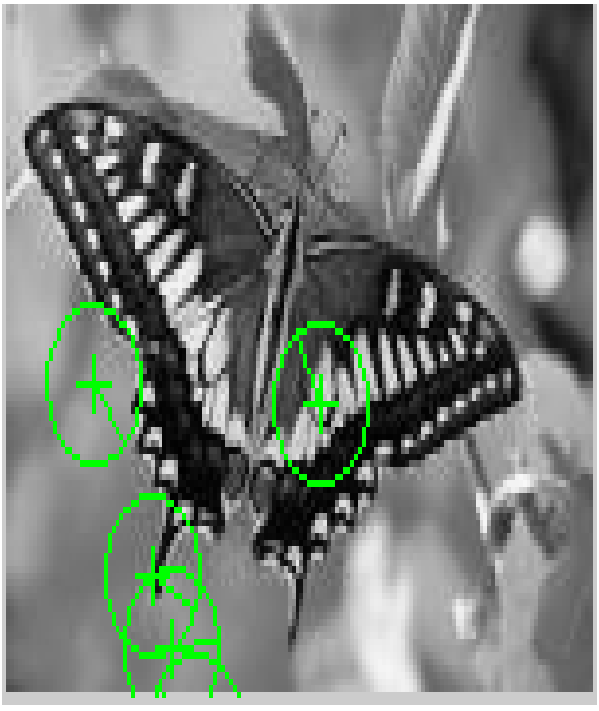

Fig 5 Represent the corner feature of an image with green point.

Corner Feature: In order to stabilize the video frames in case of moving camera it require the difference between the two frames which are point out by the corner feature in the image or frame. So by finding the corner position of the two frames one can detect resize the window in original view. This feature is also use to find the angles as well as the distance between the object of the two different frames. As they represent point in the image so it is use to track the target object.

IV. CONCLUSIONS

With the high demand of image in various fields researchers get attracted for analysis. This paper cover various approaches of haze removal of different scenes and situations. As unfavorable weather condition make high data lose, so recovering those is done by extracting features from the image. It is obtained that dark channel removal is important technique that recover image efficiently, in worst weather condition. It is also obtained that color and edge feature plays an important role for object detection in image or video frame. In future a perfect algorithm is with good feature combination is desired which can remove haze while image object get identify easily.

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