A REPORT ON

(VIDEO DEFOGGING AND VEHICLE DETECTION)

BY

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ABSTRACT

In this project, we have proposed the technique of fog removal from a video and object detection. Detecting the objects from a foggy video is very difficult. Over the past decade, many researches have been done to improve single-foggy images. In this study, an effective method of removing fog from video is presented. The video is converted to different frames and a new single image enhancement approach which is based on mixture of dark channel prior (DCP) and contrast limited adaptive histogram equalization (CLAHE) algorithms are applied on each frame. Along with the DCP algorithm using modified transmission map, we obtained a fast processing speed and clean defogged image without refining process. The CLAHE method to improve the contrast of image. Finally, the obtained enhanced frames are again converted back to video. After that object detection is being done from the obtained defogged video.

CONTENTS

INTRODUCTION

Many systems in computer vision applications, like surveillance, tracking, and navigation, object detection etc. have suffered from fog and haze since fog in the atmosphere degrades the visibility in terms of sharpness, intensity, contrast, and colour quality. The information of the scene objects is lost due to such degradation of quality. It makes the visibility of objects of a scene very poor. For example, driving in foggy weather in hill stations is difficult since the hilly roads are steep, and the possibilities of accidents are high. In most computer vision applications, we require a haze-free image or video as an input to recognise the objects and/or measure the depth (a distance of the objects from the camera system) by utilising the input images or video frames [1]. Hence many researchers have imposed their interest in developing fog/haze removal techniques [1].

In the atmosphere, fog is generated due to absorption, reflection, and scattering of atmospheric light, which come from scene objects through water droplets and other suspended atmospheric particles [2]. So the received irradiance from scene objects gets attenuated. The amount of fog present in an image is a function of the scattering coefficient and depth of the scene objects. Defogging or dehazing is a technique of elimination of fog or haze from video frames or images for improving the scene visibility in terms of intensity, colour, contrast, and other parameters.

Since the fog is a function of depth and scattering coefficient, it becomes a challenging task for a researcher to explore these unknown parameters from the foggy image frames. Generally, two different types of dehazing techniques are used in practice depending on the image frame numbers: (i) based on a single frame [2]; and (ii) based on multiple frames [2]. Only a single frame of a test image of a scene is used for single-frame defogging techniques, whereas in the case of multi-frame techniques, the fog is removed by using multiple frames of the same image scene. The acceptance of the single-frame defogging method is more because no prior information is required from the reference image like multi-frame defogging techniques. Since the last decade, many fog and haze removal techniques have been proposed. However, most of them suffer from the following limitations: (a) They fail to provide information about the whole scene in the presence of thick fog and sky region. (b) They only enhance visibility without concentrating on the improvement of the depth of the scene [1]. (c) In some cases, the colour quality, sharpness, contrast, and intensity are not correctly adjusted together.

He *et al.* [1] proposed an innovative single-image fog removal technique with a new idea of dark channel prior (DCP). The DCP is built with very low-intensity pixels or dark pixels of the colour channels of an image. The depth of the fog can be estimated easily by this method. However, it becomes inefficient to provide good results when the brightness of the scene object and the intensity of atmospheric light are approximately at the same level.

Fattal [5] developed a defogging method for colour image depending on the local colour-line model. The intensity values of pixels of small image patches are distributed in one dimension, which is shown by the proposed model. The transmission map is estimated using this colour-line model. Variable gamma correction factors are used for the accurate restoration of an image. This method is based on some specific assumptions and does not work well in the sky region.

We have used the method, in which the scene depth is estimated by DCP, and contrast limited adaptive histogram equalization (CLAHE) improves the contrast in the V channel. High- and low frequency image components are used to reduce the noise and enhance image sharpness. Sometimes, the defogged output encountered artifacts due to the operations on high-frequency components.

Computer Vision Toolbox provides algorithms, functions, and apps for designing and testing computer vision, 3D vision, and video processing systems. We can perform object detection and tracking, as well as feature detection, extraction, and matching. For 3D vision, the toolbox supports single, stereo, and fisheye camera calibration; stereo vision; 3D reconstruction; and lidar and 3D point cloud processing. Computer vision apps automate ground truth labeling and camera calibration workflows. We can train custom object detectors using deep learning and machine learning algorithms such as YOLO v2, Faster R-CNN, and ACF. For semantic segmentation you can use deep learning algorithms such as SegNet, U-Net, and DeepLab. Pretrained models let you detect faces, pedestrians, and other common objects.

OBJECTIVE/AIM

Aim of our project is to defog the video and detect moving vehicles in it.

METHODOLOGY

Fog image modelling:

An input image $I(x)$ containing fog can be used as follows in the fog model equation:

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

Where $I(x)$ is an image obtained with a camera, $J(x)$ represents the final image with fog removed, A is a global fog value that describes the degree of fog influence over all pixels, $t(x)$ is a transmission value indicating the degree of successful image capture by the camera without colour scattering, and x indicates a pixel.

First term containing the Transmission value basically is the portion of total light reflected from the scene that reaches camera after suffering attenuation from dust particles, suspended water droplets etc. present in the atmosphere. This transmission value
$t(x)$ is represented by an exponential decay function related to pixel depth, as shown in the following equation:

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

Where β is a scattering coefficient, and '$d(x)$' represents the distance from the object to the camera.

Light scattered by the particles in atmosphere appears as atmospheric light which is the second term in the fog image model.
This term introduces the veil like effect which haze opaque the pixels for distant object for which intensity is already low due to exponential decay all along distance.
First term that is the multiplicative attenuation and second term that is the additive attenuation, combined gives the foggy image.

Dark channel prior (DCP):

As the name suggests this method of fog removal is based on the assumption that for a haze free image the at least one of the RGB colour channel values of pixels converges to zero.
Concept of dark channel for an image can be formally described by the following equation:

$$J^{dark}(x) = {}^{\min}{}_{c \in (r, g, b)}[{}^{\min}{}_{y \in \Omega(x)}\,(J^c(y)] \qquad (3)$$

Where Jc is a colour channel of J and 'y' is a local patch centred at x.
A dark channel is the outcome of two minimum operators: min $_{c \in (r, g, b)}$ is performed on each pixel, and min $_{y \in \Omega(x)}$ is a minimum filter. As a result, dark channel for haze free image tends to zero.

Jdark → 0

The effect of two min operators can be clearly observed in the images below.

Fig-1(a) haze free image (b) with min of rgb values (c)with minimum filter performed on b

Modified DCP:

As DCP uses a patch by patch , so with the conventional DCP algorithm, a restored image is liable to show a halo phenomenon caused by fog that was not removed from boundary areas of the image and areas with abrupt contrast.

So in this project a modified approach is used for defogging by modifying the DCP. This modified DCP is given as follows

$$J^{dark}(x) = {}^{\min}{}_{c \in (r,\, g,\, b)}(J^{c}(y)). \qquad (4)$$

how this modified DCP is used is encountered as we move ahead in this report.

FOG REMOVAL FROM A SINGLE FRAME:

Fog removal from a foggy image mathematically implies deriving 'J' from fog image model equation that includes step by step process of finding out transmission map t(x), atmospheric light 'A' and finally obtaining the scene radiance J.

Obtaining the transmission map: in the convention DCP method the equation for transmission map was obtained by normalizing the fog image equation by atmospheric light and then applying the minimum filters as in dark channel equation this resulted in zero valve for the scene radiance part and taking uniform transmission within a patch t(x) was obtained as

$$t(x) = 1 - \omega \times [{}_{c \in (r,\, g,\, b)}\min({}_{y \in \Omega(x)}\min\ (Ic(y)/Ac)] \qquad (5)$$

or. $t(x) = 1 - \omega \times [\text{dark channel of } (Ic(y)/Ac)]$.

Applying the modified dark channel in above equation gives the modified transmission map as

Modified transmission equation → $t(x) = 1 - \omega \times [{}_{c \in (r,\, g,\, b)}\min(\ (Ic(x)/Ac)] \qquad (6)$

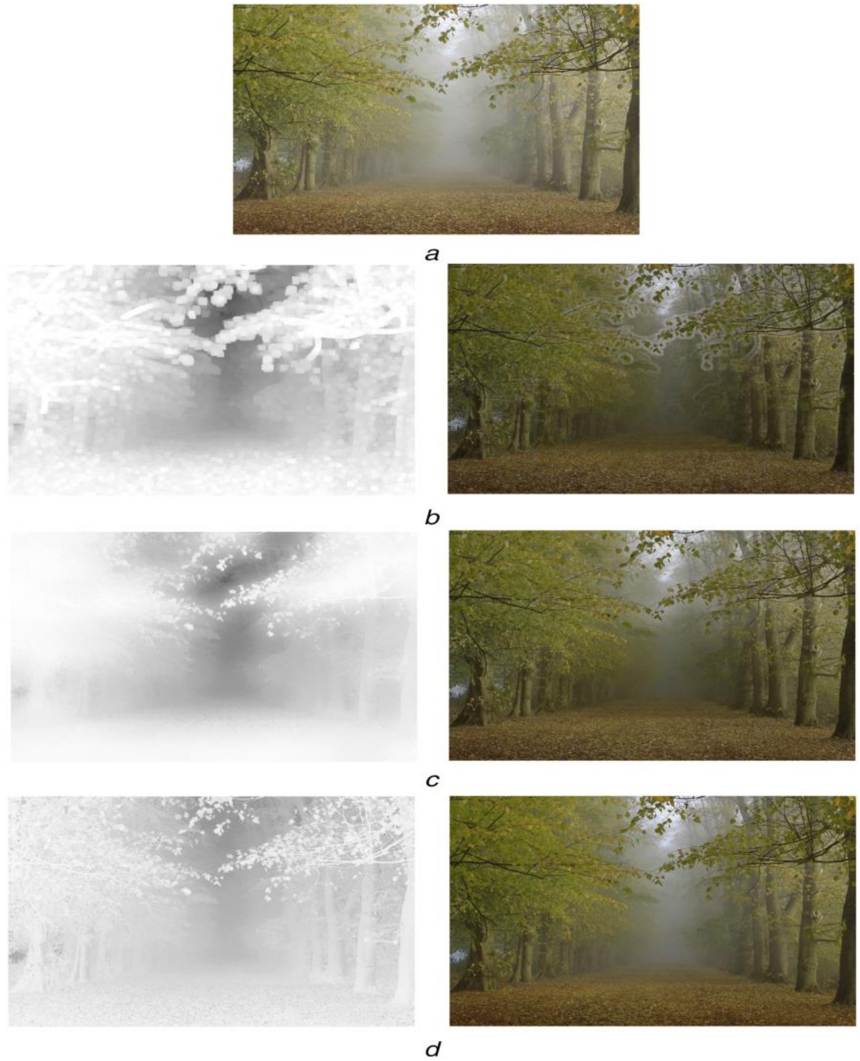

Fig.2:(a) foggy image (b) transmission map and defogged image after DCP (c) after DCP and matting (d) after modified DCP.

Above figure show the comparison between transmission map and output defogged image from DCP and modified DCP.

Modified DCP gives result equivalent to DCP with matting which is a complex and time consuming process. DCP method is incapable of giving artefact free result hence need to be combined with soft matting whereas modified DCP yields similar result without any kind of refining process.

Obtaining atmospheric light: pixels for depth objects have so less radiance intensity that they tend to become haze opaque due to the effect of atmospheric light and hence give the effect of fog. So in the dark channel the haze effect area in the image appears as hight intensity pixels whereas intensity for least haze affected non-sky regions tends to zero so appears as dark pixels.

Hence atmospheric light is estimated by taking the average of top 0.1% brightest intensity pixels.

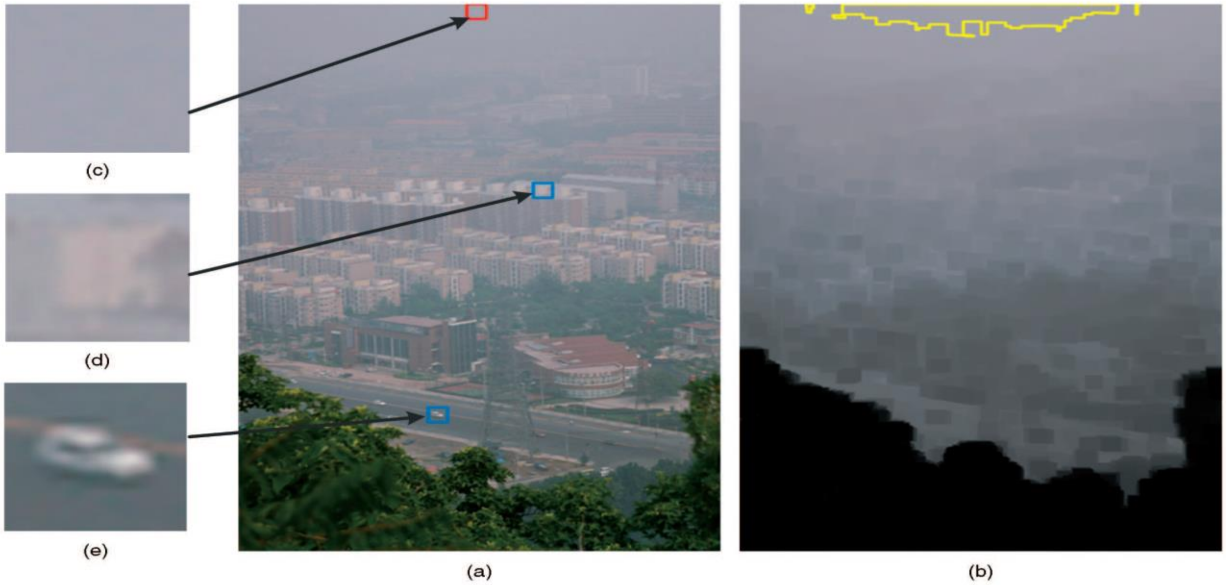

Fig. 3.(a) foggy image (b) dark channel for the foggy image (c)pixels used for determining the atmospheric light (d),(e) pixels with intensity greater than atmospheric light.

Above image shows the bright pixels which are considered to calculate the atmospheric light that are present in the fog affected regions of image. There are some pixels with intensity brightest than the atmospheric light represented by (d) and (e). If there are large number of such pixels with intensity greater than the atmospheric light as in case of snowy region or sky region then atmospheric light estimation becomes tricky. So this method works well for non-sky region but also can gracefully handle even for pictures with sky region to some extent.

Obtaining the scene radiance: after obtaining the transmission map and atmospheric light, scene radiance that is the final defogged image can be obtained from the for image model equation i.e equation 1. Point to be focused while recovering scene radiance is that when $t(x)$ tends to zero then direct attenuation term becomes zero which makes the obtained scene radiance prone to noise so transmission map is restricted by a lower bound t_0, typical value for which is taken to be 0.1.
So equation for scene comes out to be as

$$J(x) = A + (I(x) - A)/ \max(t(x),t_0) \qquad (7)$$

CLAHE for contrast enhancement: CLAHE is a classic histogram equalisation technique in which enhances the local details of an image through local contrast enhancement. CLAHE is a variant of Adaptive histogram equalization (AHE) which takes care of over-amplification of the contrast. It operates on small patches of image rather than the entire image and then the adjacent patches are combined to remove the artificial boundary. For colour images CLAHE is applied on the luminance channel rather than applying it on RGB channels for better equalization.

RESULTS

1. Initially the video was de-framed to string of images.

Fig. 4: Frames of video to be defogged

2. Foggy Image:

Fig. 5(a): Foggy frame

3. DCP :

Fig. 5(b) Frame through Dark Channel Prior

It is observed that dense fog image through a simple Dark Channel Prior(DCP) algorithm gives a dark output leaving the user wonder if it is day or night since the defogging is happening without reference and this result may not be of much use in practical sense. Hence, we went ahead to modify the DCP algorithm such as to work reasonably fair in most cases.

4. Modified DCP:

Fig. 6: Modified DCP Image

Here we can evidently justify the working of modified DCP. Though this is reasonably good enough for our object detection task, Image enhancement was a field to work on to get a better quality image. The first step towards it, we explored the CLAHE algorithm.

5. CLAHE:

Fig. 7: CLAHE output

It has been noticed that CLAHE intensifies the contrast. And we learnt that handling the contrast alone would not lead us to a better quality of Image and hence suggested in future work.

6. VEHICLE DETECTION:

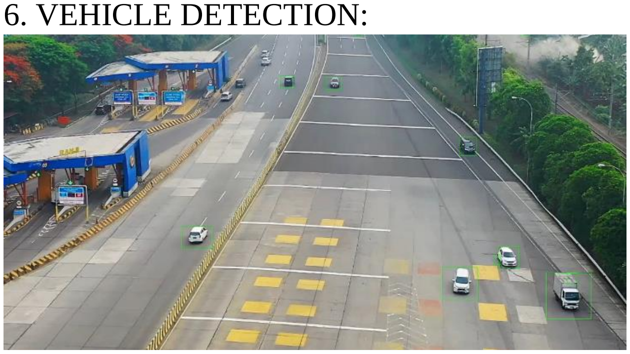

Fig. 8(a): Vehicle detection in completely haze free video.

Fig. 8(b) Vehicle detection in defogged video.

CONCL

This work is merely a combination of ideas in the field of defogging. Our attempt to defog a video using single frame dehaze technique using a modified version of Dark Channel Prior method is a beginner's step in dehazing techniques. The defogged video, hence used for vehicle detection is a highlight of one such application of defogging/de-hazing techniques.

FUTURE WORK

With Partial Fulfillment, we would like to see the broad extensions of this work that can be made possible. Beginning with, Image sharpness and contrast enhancement techniques could be emphasized. The vehicle detection can be taken forward to vehicle count and tracking. To make the work more practically feasible, this can be pushed for real time analysis.

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