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Survey on Image Fog Reduction Techniques

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Abstract - Image contrast often significantly suffers from degradation due to haze, fog or mist spread in atmosphere, and adds more atmospheric light that harms the visibility of image. In this paper, various methods for reduction of fog have been analyzed and compared. The methods described in this paper are immune to the bad weather conditions including haze, fog, mist and other visibility issues caused by aerosols. Furthermore, the most optimum method is determined for processing RGB images.

Keywords – *Image Defogging, Albedo, Dark Channel Prior, Transmission Map, Bilateral filtering, CLAHE.*

1. Introduction

Visibility of images often suffers due to fog, mist, and haze present in atmosphere. However, it plays very important role in day to day life such as in video surveillance, navigation control, satellite imaging like environmental studies, weather studies, web mapping and vehicle driving, railway and road traffic analysis. Images which are captured under foggy or hazy weather contains atmospheric degradation particle, as a result light incident on scene get absorbed and scattered. There are many elements which reflect the incident light, bring downs saturation level. This affects low as well high frequency components of the image. Moreover, this degraded image suffers severe contrast loss, bad visibility, very poor performance. Due to contrast loss image dim especially in distant regions and blurred with surrounding area. In order to get rid of this problem, it is necessary to defog the degraded image [7][8].

Fog formation occurs due to condensation of water vapor into tiny droplets suspended in the air. Water vapor is added to the air in various ways such as wind convergence, water fall, heating of water due to sunlight cause evaporation of water from the surface of oceans, estuary and transpiration from plants and lifting Air Mountain. Produced water vapor begin condensing on dust, ice, salt and other particles which are present in atmosphere, in order to form cloud. Fog forms when a cool, stable air mass is trapped underneath a worm and humid air mass, this process make substantial effect on images and lack visibility and visual vividness in a real time system.

In this paper, we explore and compere various technique like soft matting, dark prior channel to reduce foggy effect from the image.

2. Literature Survey

Conventional schemes of image capture result in a degraded image in bad weather conditions which is difficult to reconstruct. Haze removal from a single image remains a challenging task as haze is dependent on unknown depth information. Over the years many researchers have attempted to overcome this turmoil.

R. Fattal [1] proposed a new method which is able to restore image as well as find a reliable transmission map for additional applications such as image refocusing and neon vision. Based on refined model, image is broken down into segments of constant albedo. It is assumed that surface shading and medium transmission are statistically uncorrelated. It uses a single input image. Results are physically sound and produce good result, although it cannot handle heavy images. Also it fails in case the assumption of surface shading and medium transmission being statistically uncorrelated is not met.

Tan's [2] method observed that haze free image must have higher contrast compared to input image. It maximizes local contrast. Dark channel prior used in this method. Atmospheric light is estimated from sky region. Transmission is estimated from coarse map by redefining fine map. Two simple filters are combined on basis of local pixel information therefore computation cost is reduced. Results are visually appealing, but physically not valid. Results are over saturated. Transmission may be underestimated.

Tarel [3] coined in a method that improves meteorological visibility distances measured in foggy whether by using a camera on a moving vehicle. It is dynamically implementing Koschmieder's Law which relates apparent contrast of image with sky background, at known observation distance, to the inherent contrast and to the atmospheric transmissivity. Meteorological visibility distance measure defined by the International Commission on Illumination (CIE) as the distance beyond which a black object of an appropriate dimension is perceived with a contrast of less than 5%. It is statistically better than [4], in terms of visibility levels. It uses median filter to compute atmospheric veil which brings out severe atmospheric veil discontinuities.

(a) (b)

Fig. 1. (a) Original acquired image
(b) Tarel's result with atmospheric veil discontinuities.

Zhang [4] performed visibility enhancement using image filtering. Based on Tarel et al's approach. [6] Enhanced by using dimension reduction to correct preliminary haze layer estimation. He developed a new filtering approach based on projection onto the signal subspace spanned by the first K eigenvectors. Noise reduction and Texture reduction is also performed. It takes longer time to compute than Tarel's method.

He et al [5] used guided image filtering, and proposed simple but effective method for haze removal using dark channel prior method. Most images contain haze free portion which has very low intensity in at least one color. Therefore, thickness of haze may be directly calculated. Output of one filter may be the input for the next guided filter. It can be used for edge preserving and smoothening, and has better results than the popular bilateral filter. It has a significantly faster processing time. A high quality depth map is also created. May not work for images with objects inherently similar to the atmospheric light, transmission then will be underestimated as dark channel has statistical dependence.

Xu et al [9] have proposed an improved dark channel prior method. They have replaced the time consuming soft matting process with a fast bilateral filter. Conventional algorithm are not suitable for sky region. Therefore they used weaker methods to make the new algorithm more flexible. Contrast limited histogram equalization (CLAHE) was proposed by them in order to reduce contrast of the image.

The basic fog image model used for the removal of fog from image is as follows:

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

Where J(x) is the Scene Radiance, A (1-t(x)) is Airlight and t(x) is the Medium Transmission. Different parameter of the equation (1) is illustrated in [5]. Direct attenuation will be zero in case t(x) tends to zero. In order to avoid such an ambiguity t(x) is restricted to a lower limit t_0.

3. Proposed Image Defogging Algorithm

The proposed algorithm for haze removal from image has tried to combine the existing method of fog removal using dark channel prior and image enhancement of defogged image. The flow chart for the algorithm is shown in fig 2. It contains various steps of the algorithm are described as follows:

I. The foggy image is passed through the system.
II. The dark channel of foggy image is calculated.
III. The transmission ratio is estimated using atmospheric light.
IV. Transmission ratio is redefined to remove the halo artifacts from the edges.
V. Haze free image is recovered using equation (5).
VI. Image enhancement of haze free image by applying CLAHE on R, G and B component separately and histogram equalization.

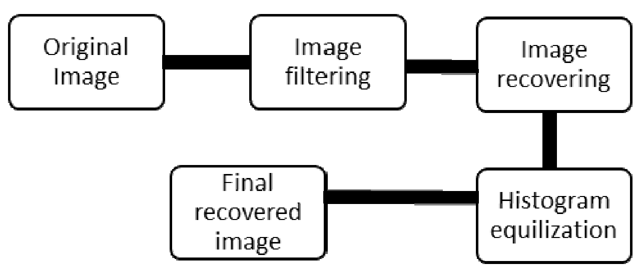


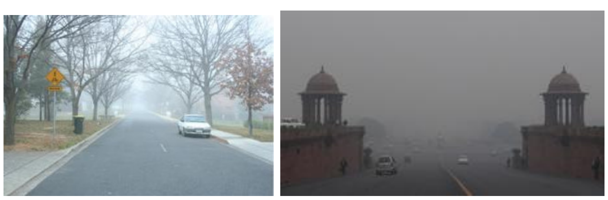
Fig 2. Flow diagram for the proposed algorithm

In [6], the airlight was determined from a foggy image by using a patch of fixed size i.e. 15. This method is efficient in variety of images. However, in image with multiple sources of light, this method becomes inefficient. This is because the filter with small patch size may pick up the light source which may lead to wrong estimation. This can be eliminated by using large patch size. In this proposed work, patch size 25 is used.

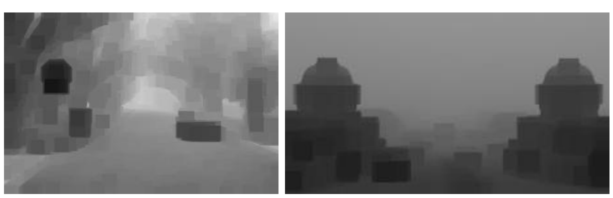
In estimation of scene radiance, the typical value of t_0 can be 0.1. However for an image containing substantial sky regions this value needs to be increased which may result brighter and smoother the sky region. In our work, the value of t_0 is 0.30.

4. Results

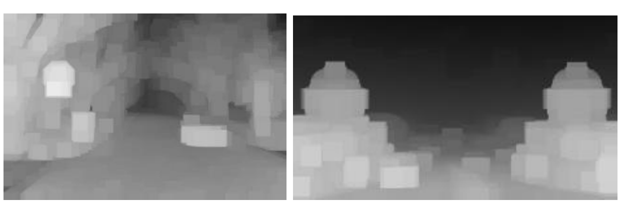
Fig (3) shows various steps involved in the proposed algorithm which includes steps for fog removal from image followed by image enhancement using contrast limited adaptive histogram equalization on R, G and B components separately.



(a)



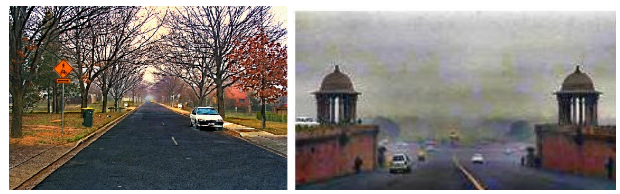
(b)



(c)

(d)

(e)



(f)

Fig. 3. Results of various steps of the proposed algorithm on two different images.

(a) Original images with foggy effect
(b) Dark channel of foggy images
(c) Transmission map of the respective images
(d) Redefined retransmission map to remove the halo artifacts
(e) Recovered image in the form of scene radiance.
(f) Enhanced image using CLAHE algorithm on R, G and B components separately

As it can be observed from fig 3. (b), Tan's method reduces fog but produces unnatural output image with stark edges. He et al method, in fig 4. (c), produces the most accurate results among the three and has faster computational speed. From fig. 4. (d), it can be seen that Tarel's method is statistically correct but is not able to completely remove the haze.

(a) (b)

(c) (d)

Fig 4. Visual comparison of various techniques for fog removal from image (a) Original image (b) Tan's method (c) He et al's method (d) Tarel's method

(a)

(b)

Fig.5. Visual comparision of He et al's results with the results of the proposed algorithm (a) He et al's output (b) Output of proposed method.

From fig 5., the output of the proposed algorithm has more defined details than original He et al's result. In [5], the airlight was determined from a foggy image by using a patch of fixed size i.e. 15. This method is efficient in variety of images. However, in image with multiple sources of light, this method becomes inefficient. This is because the filter with small patch size may pick up the light source which may lead to wrong estimation. This can be eliminated by using large patch size. In this proposed work, patch size 25 is used.

5. Conclusion and Future Scope

Vision surveillance systems and other such applications should be able to overcome the constraints caused due to bad weather. In many cases, fog and mist blurs the clarity of the recorded video. The video does not define details, which may cause severe security lapses. This paper attempts to understand and exploit the manifestations of whether. It compares various existing algorithms for fog reductions as well as characterizes their key advantages as well as shortcomings. Various methods image defogging technique proposed by Fattal, Tarel, Tan and He et al are compared with the proposed improved algorithm. The existing model in atmospheric optics is studied and a new approach is devised by optimizing the threshold value for atmospheric value and patch size and by using image enhancement technique. The output hence obtained has defined objects and object boundaries which may also have applications in real time sports coverage and news broadcast. However, in the proposed algorithm, the soft matting technique used for redefining the transmission is very time consuming, so the utility of algorithm is limited to images of small size.

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