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Research Paper

REAL TIME IMPLEMENTATION OF HAZE REMOVAL ALGORITHM

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Human eye has many limitations, one of it is looking though haze. Number of algorithms have been proposed for removing haze from an image. Some of them are good in contrast gain, some independent of thickness of haze and many more but for real time implementation quality of output and execution time both are to be considered simultaneously. Here by we propose a set-up which uses raspberry pi and minimized color attenuation prior algorithm for removing haze from an infrared camera input and display the output on display unit in real-time scenario.

Keywords: De-hazing, Real time de-hazing, Video de-hazing, Real time implementation

INTRODUCTION

The visibility of human eye as well as a camera tend to decay as the thickness of haze or fog increases. In bad weather, many security set up fail to work effectively and ultimately lose the important information which was to be preserved .Considering a scenario in which surveillance camera has been set up at traffic signal, At clear nights the camera is able to identify the colour of vehicles, registration number etc. but at hazy nights it will surely fail to identify the vehicle depending on the thickness of haze. This is hardware limitation of the camera which can be overcome using digital image processing software which fits perfect in the scenario. Many scenarios need accuracy and many need real time implementation, thereby there is need of an optimized accurate real time algorithm for above mentioned scenario.

After introduction of digital image processing, many algorithms have been proposed for de-hazing the single image. Most popular among them are namely Dark Channel Prior, Color Attenuation Prior and Bilateral Filter. All of these algorithms have different set of qualities and excel in some or the other applications. Considering their popularity we have studied and implemented these three algorithms to find out best out of them for our project and then optimized the same for more real time compatibility.

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LITERATURE SURVEY

Dark Channel Prior Algorithm

This algorithm says that in most of the non- sky patches some pixels have a very low intensity in at least one of its color channels (RGB). This color channel having relatively low intensity is referred as dark channel. In the hazy image these dark pixels can be used to determine the true air-light since the air-light is apparent on a dark object. The dark channel J dark of J(the haze-free image) is defined as

$J\ dark(x) = min \in \{r,g,b\}\ min\ y \in \Omega(x)\ (J\ c\ (y))!$

where J c is a color channel of J and Ω(x) is a local patch centered at x. This statistical observation is called the dark channel prior. These low intensities come from natural phenomena such as shadows or just really dark or colorful surfaces. Since J dark tends to be zero and as Ac, the corresponding channel of the atmospheric light is always positive, it may be written by

$J\ dark(x) = min\ c \in \{r,g,b\}\ min\ y \in \Omega(x)\ J\ c\ (y)\ Ac\ ! = 0$

$min\ c\ min\ y \in (x)\ I\ c\ (y)\ ! = et(x)\ min\ c\ min\ y \in \Omega(x)\ J\ c\ (y)\ ! + (1 - et(x))$

with *et(x)* denoting the transmission in patch

$et(x) = 1$ “ $min\ c\ min\ y \in \Omega(x)\ I\ c\ (y)\ Ac\ !$

which is a direct estimation of the transmission for each local patch. They then apply a soft matting algorithm on the depth map, this leads to a much smoother Having the transmission or depth map, the scene radiance can now be recovered. However, since the direct attenuation term J(x)t(x) can be very close to zero, the transmission is restricted to a lower bound t0 for example t0 = 0.1, since the scene radiance is typically not as bright as the atmospheric light A.

The final scene radiance J(x) may then be recovered by

$J(x) = I(x)$ “ $A\ max\ (t(x), t0) + A.$

In the above calculations, the atmospheric light A was considered to be known, which is of course not the case, at least initially. Unlike other workers in the field, He *et al*. do not take the pixel with the highest intensity as the atmospheric light, since this could as well be a white surface such as a white airplane or a bright building veneer. He et al. pick the top 0.1% brightest pixels in the dark channel (min c(I c)), since these must be the most hazeopaque. Among these pixels, the pixel with the highest intensity in the input I is picked as the atmospheric light A. This may not be the brightest pixel in the image, but is more robust than the “brightest pixel” method.

Bilateral Filter

This filter is a nonlinear filter that does spatial averaging without smoothening of edges. It has emerged as an effective image de-noising technique. It also can be applied to the blocking artefact reduction. An important issue with the application of the bilateral filter is the selection of the filter parameters, which affect the results significantly. Another research interest of bilateral filter is enhancement of the computation speed.

The bilateral filter takes a weighted sum of the pixels in a local neighbourhood; the weights depend on both the spatial distance and the intensity distance. In this way, edges are preserved well while noise is averaged out. Mathematically, at a pixel location x, the output of a bilateral filter is calculated as follows

$$\tilde{I}(\mathbf{x}) = \frac{1}{C}\sum_{y\in N(x)} e^{\frac{-\|\mathbf{y}-\mathbf{x}\|^2}{2\sigma_d^2}}\, e^{\frac{-|I(\mathbf{y})-I(\mathbf{x})|^2}{2\sigma_r^2}}\, I(y)$$

where d and r are parameters controlling the fall-off of weights in spatial and intensity domains, respectively, ( ) N x is a spatial neighbourhood of pixel ( ) I x , and C is the normalization constant

$$C = \sum_{y \in N(x)} e^{\frac{-\|\mathbf{y}-\mathbf{x}\|^2}{2\sigma_d^2}} e^{\frac{-|I(\mathbf{y})-I(\mathbf{x})|^2}{2\sigma_r^2}}$$

Another parameter during the running of the bilateral filter is the window size of how many pixels should be computed on time. The window size is related to the spatial Gaussian.

Basically, based on the property of the Gaussian distribution, window size should be around 2 to 3 times the standard deviation of the Gaussian, since when it's over 3 times sigma, the output of Gaussian almost equals to zero.

There are two parameters that control the behaviour of the bilateral filter [1]. Referring to above equation, d and r characterize the spatial and intensity domain behaviours, respectively. In case of image de-noising applications, the question of selecting optimal parameter values has not been answered from a theoretical perspective; to the best of our knowledge, there is no empirical study on this issue either. In this section, I provide an empirical study of optimal parameter values as a function of noise variance.

Color Attenuaton Prior Algorithm

This algorithm removes haze from an image by creating a linear model for modelling the scene depth of the hazy image also the depth information can also be recovered. With the depth map of the hazy image, we can easily estimate the transmission and restore the scene radiance via the atmospheric scattering model, and thus effectively remove the haze from a single image. Experimental results show that the algorithm is quite effective in terms of both efficiency and the de-hazing effect.

The brightness and the saturation of pixels in a hazy image changes sharply along with the change of the haze concentration. This information is available before the execution of de-hazing algorithm and hence it is called as color attenuation prior algorithm. In an image without haze, both brightness and the saturation of image has least saturation difference and in the hazy image the brightness increases and saturation decreases ultimately increasing the value of saturation difference drastically, depending on the thickness of haze in the image.

Figure 1: (a) A Hazy Image. (b) The Close-up Patch of a Dense-haze Region and Its Histogram. (c) The Close-up Patch of a Moderately Hazy Region And Its Histogram. (d) The Close-up Patch of a Hazefree Region and Its Histogram.

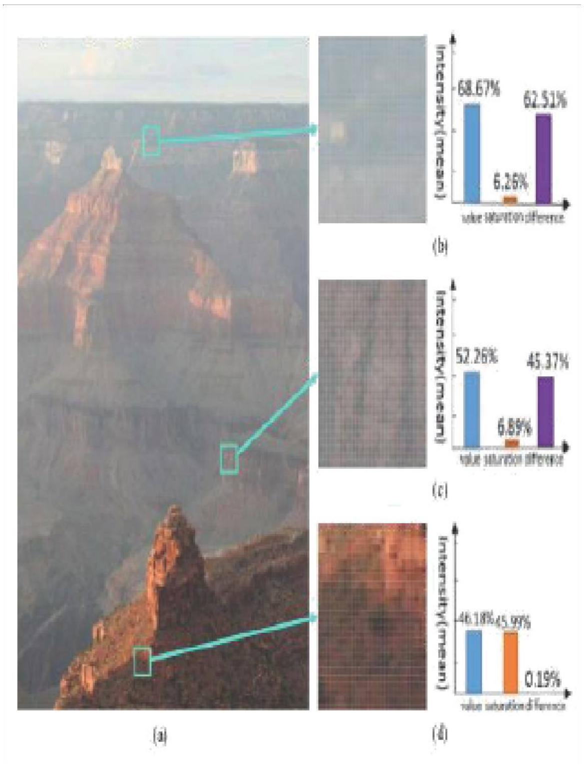

Figure 1 gives an example with a natural scene to show how the brightness and the saturation of pixels vary within a hazy image. As illustrated in Figure 2(d), in a haze-free region, the saturation of the scene is pretty high, the brightness is moderate and the difference between the brightness and the saturation is close to zero. But it is observed from Figure 2(c) that the saturation of the patch decreases sharply while the color of the scene fades under the influence of the haze, and the brightness increases at the same time producing the high value of the difference.

Using this the depth map of the image is produced and then the part having less value saturation difference is subtracted from input image and them the hazy part of image is processed and output is generated.

1. Dark Channel Prior

Figure (a): Input and Output Images After Applying Dark Channel Prior Algorithm

The details in the dark channel prior are recovered the best also the saturation and contrast of the image comes out to be natural but the parameter where dark channel prior fails to perform is execution time. It needs 20 seconds and more to process a single image. Therefore it is really difficult to implement it in real time scenario.

2. Bilateral Filter

Figure (b): Input and Output Images After Applying Bilateral Filter

The bilateral filter failed to remove the uniformly distributed haze from the image.. Also the time required for execution is 10 seconds and more. Therefore Bilateral filter is only useful to removed point and line noise.

2. Color Attenuation Prior

Figure (c): Input and Output Images After Applying Color Attenuation Prior Algorithm

The color attenuation prior gives acceptable output. The image has less contrast gain when compared to dark channel prior but the execution time is 5 to 10 times less than the dark channel prior.

Therefore Color attenuation Prior Algorithm is best fit algorithm for real time implementation. The future work on this paper will be the implementation of the minimized color attenuation prior algorithm using raspberry pi for real time applications. This will be a really useful for many security and safety sectors.

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