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Enhanced DCP filter for Real-World Hazy Scenes

Sanjay Sharma, Padma J Bonde
Shri Shankaracharya Technical Campus, Bhilai
sansh_496@yahoo.com
bondepadma@gmail.com

Abstract – Haze is an atmospheric phenomenon that considerably degrades the visibility of out- door scenes. This happens due to atmosphere particles that absorb and disperse the sunshine. This paper introduces a unique single image visibility restoration algorithm that enhances visibility of such corrupted pictures. A unique edge-preserving decomposition-based technique is prepared to estimate transmission map for a haze image. Therefore, haze removal algorithmic rule has been taken from Koschmiedars law that includes a quick replacement-variation approach to dehaze and denoise at the same time. The proposed technique Enhanced DCP Filter (EDCPF) initially estimates a transmission map employing a windows adaptive technique that supported the dark channel. Restoration of foggy images is an important issue for the de-weathering in computer vision. A new method has been introduced for estimating the optical transmission in hazy scenes. Based on this estimation, the scattered light is eliminated to increase scene visibility and recover haze-free scenes.

***Keywords**: Retinex theory, Visibility restoration, dehazing, Edge-preserving regularization, Fusion technique and MATLAB*

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I Introduction

A main objective in dehaze analysis is improvement of visibility and recovery of colors. The requirement for image improvement from the actual fact, that the atmosphere is rarely free from particles. Even simply pure air, the visibility has been found to be between 277m [1] to 348m [2], while [3] has not considered the curvature of the earth's surface. However, real visual ranges are not up to theoretical worth. The international visibility codes for meteorological will vary visibility rate between 50m and 50km for exceptionally clear air. These codes are found to reflect a convenient scale for visual ranges within the daily work of meteorologists. Recently, haze removal method through single image attracted a lot of interest and created important progresses because of its broad applications.

Several single image haze removal algorithms were planned and supported haze-free image that has higher quality than its haze image. A stimulating single image haze removal algorithmic rule was planned in [5] by increasing the native distinction of the fixed up image. Experimental results show that the planned algorithmic rule is applicable to haze pictures, underwater pictures and traditional pictures which are not haze. It ought to be detected and planned algorithmic rule from the Koschmiedars law, may be a new framework for signal image haze removal method.

Often, the images of outdoor scenes are degraded by bad weather conditions. In such cases, atmospheric phenomena like haze and fog degrade the visibility of the captured scene. Since the aerosol is misted by additional particles, the reflected light is scattered and as a result distant objects and parts of the scene are less visible, which is characterized by reduced contrast and faded colors. Outdoor images are often suffered by suspended atmospheric particles such as haze, fog, smoke and mist that reduce the quality of the images taken in the scene. Visibility, contrast, and vividness of the scene are drastically degraded, which make it more difficult to distinguish objects.

De-weathering means enhancing the image quality acquired in poor weather conditions and Enhancing image quality is critical issue in applications such as aerial photography, driving assistance and visual surveillance. Defogging is a representative de-weathering problem especially for removing the weather effect caused by suspended aerosol and water drops. The goal of defogging is to improve the contrast of the foggy images and restores the visibility of the scene.

Many outdoor applications like video surveillance, object detection, object recognition, tracking, intelligent vehicles and remote sensing systems etc. We assume that the input images have clear visibility. Unfortunately, this is not always true in many situations, in particular, haze and fog weather occurring more and more frequently. Outdoor images or videos are usually degraded by light scattering and absorbing from the aerosols, such as dust, mist, and fumes in the atmosphere, here regarded as haze. The captured scenes in a bad weather affected from poor visibility, contrast, brightness, luminance and distorted color. With the help of Atmospheric optics theories, one can explain the effects that haze has on the visibility of a scene. Moreover, with the development of computer graphics technology, it is possible to improve the visibility in terms of range and color of the image. Herein, the term dehazing means to produce an image of a scene that does not contain haze affect.

Figure 1 Hazy input image (left) and the dehazed image (right).

II Related Work

There are so many common edge detection methods used in image segmentation i.e. Sobel, Canny, Prewitt, Roberts, and fuzzy logic methods. The most powerful edge-detection method is the Canny method that provides smooth edge. The Canny method differs from the other edge-detection methods because it uses two different thresholds (to detect strong and weak edges) and includes the weak edges in the output only if they are connected to strong edges. This method is more likely to detect true weak edges.

Figure 2 Image segmentation using the Canny method

In the case of a noise free image, the edge angle can be measured accurately. But, in real images, noise cannot be avoided and it is difficult to estimate the true edge angle. Kittler suggested three methods to improve the edge angle estimation obtained from Sobel's operator. All the three methods involve a variation in the output of the Sobel's operator over a 3 x 3 window. One of the methods, which ignores the effect of the central pixel, at which the angle estimate is wished to produce the best result. [2] faced some problems of edge and region detection from a new angle. It is observed that the image is a noisy image. Each region in the image is a sloped plane. In order to determine the edge between two pixels, best fitted sloped planes over a neighborhood of each pixel are found. Edges are declared at different locations having different planes on either side of them. The least square error procedure has been used to estimate the parameters of a sloped surface for a given neighborhood. An appropriate F statistic is used to test the significance of the difference of the estimated slope from a zero slope or the significance of the difference of estimated slopes of adjacent neighbors.

Figure3 Image segmentation using the Sobel method

It is observed that the concept of fuzzy sets can be used an array input pattern values denoting the degree of possession of certain properties and in representing linguistically phrased input features, at the classification level in representing multi-class membership of an ambiguous pattern and in providing an estimate or a representation of missing information in terms of membership values. In other words, fuzzy set theory may be incorporated in handling uncertainties arising from deficiencies of information. The deficiencies may result incomplete. While the applications of fuzzy sets in cluster analysis and classifier design were in the process of development.

Figure 4: Image segmentation using a Fuzzy Logic method

III Enhanced DCP Filter Technique

Propose a new haze removal technique (EDCP) for a single input hazy image using dark channel prior with haze imaging model. First we have to model the haze image by:

$$\frac{I^C(X)}{A^C} = t(x)\frac{J^C(x)}{A^C} + 1 - t(x) \qquad (1)$$

Estimate the transmission from this normalized haze equation by:

$$\tilde{t}(X) = 1 - \min_{y\in\Omega(x)}(\min_{c}\frac{I^C(y)}{A^C}) \qquad (2)$$

Then the scene radiance is recovered by the following equation:

$$J(X) = \frac{I(x) - A}{\max(t(x), t_0} + A \qquad (3)$$

The dark channel J^{dark} of J (the haze-free image) is defined as:

$$J^{dark}(x) = \min_{c\in\{r,g,b\}}\left(\min_{y\in\Omega(x)}(J^C(y))\right) \quad (4)$$

Where J^c is a color channel of J and (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:

$$J^{dark}(x) = \min_{c\in\{r,g,b\}}\left(\min_{y\in\Omega(x)}\frac{J^C(y)}{A^C}\right) = 0 \quad (5)$$

This can be used to estimate the transmission for that patch (x) by putting 5 into the image formation model 2, however now in combination with the min operator:

$$\min_c\left(\min_{y\in\Omega(x)} I^C(y)\right) = \tilde{t}(x)\min\left(\min_{y\in\Omega(x)} J^C(y)\right) + (1-\tilde{t}(x))\cdot A^C \quad (6)$$

The (x) denoting the transmission in a local patch, then putting 5 into 6 leads to:

$$\tilde{t}(x) = 1 - \min_c\left(\min_{y\in\Omega(x)}\frac{I^C(y)}{A^C}\right) \quad (7)$$

That is the direct estimation of the transmission for each local patch. They apply a soft matting algorithm on the depth map, lead to a much smoother and detailed depth map, having the transmission or depth map, the scene radiance according to 2 can now be recovered. 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:

$$J(x) = \frac{I(x) - A}{\max(t(x), t_0)} + A \quad (8)$$

In the above calculation, the atmospheric light A to be considered known.

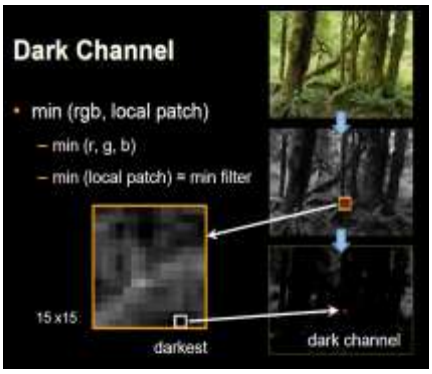

Figure 5 Dark Channel Model

At present, most outdoor video-surveillance, driver-assistance and optical remote sensing systems have been designed to work under poor visibility and weather conditions. Poor visibility often occurs in foggy or hazy weather conditions and can strongly influence the accuracy or affect the general functionality of such vision systems. Consequently, it is important to import actual weather-condition data to the appropriate processing mode. Recently, significant progress has been made in haze removal from a single image. Based on the hazy weather classification, specialized approaches, such as a dehazing process, can be employed to improve recognition. Figure 6 shows a sample processing flow of our dehazing program.

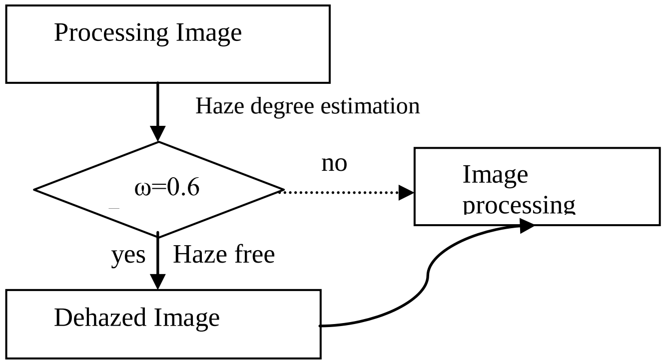

Figure 6 Dehazing Process Diagram
by using haze degree estimation

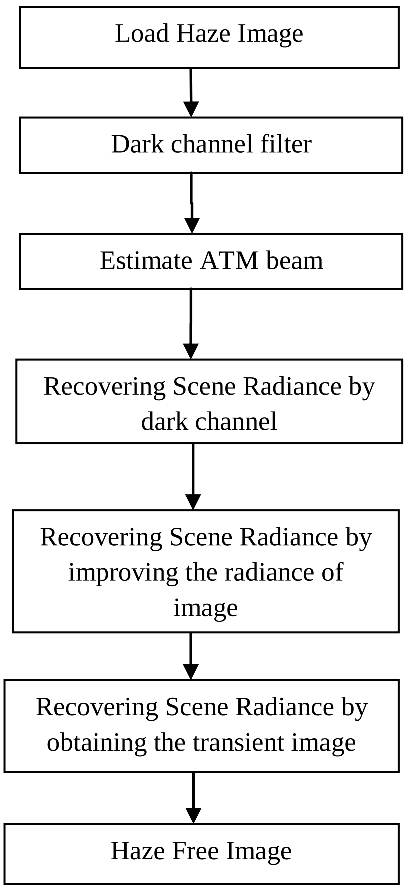

Figure 7 EDCP Filter flow diagram

 ISSN: 2321-8169
191 – 196

The Enhanced DCP Filter (EDCPF) is the combination of Edge-Preserving Decomposition and DCP. While, Edge-preserving Decomposition-based method is introduced to estimate transmission map for a haze image so as to design a single image haze removal algorithm from the Koschmiedars law without using any prior. In particular, weighted guided image filter is adopted to decompose simplified dark channel of the haze image into a base layer and a detail layer. The transmission map is estimated from the base layer, and it is applied to restore the haze-free image. A replacement model is made up to decompose the simplified dark channel of the haze image into two layers. Edge-preserving process is a technique that smoothes away textures with sharp edges. Examples are the bilateral filter, the guided filter and anisotropic diffusion. One among the foremost common edge-preserving smoothing techniques is predicated on native filtering. The bilateral filter (BF) is widely used because of its simplicity. Although, Bilateral filter (BF) may suffer from "gradient reverse".

IV EDCP Filter Analysis

Hazy images are analyzed and the following are the results.

Figure 8 Input Image with Haze

In figure 8 (input image), it is observed the hazy image and used a haze removal technique (EDCPF). In above input object, apply dark channel estimation algorithm as shown in figures 1 and 2 and find dark region with light intensity of object. After the collecting dark information in object, we mark it as show in figure 9.

Figure 9 Dark Image after haze removal

The first output is a dark form of image after removing haze. After applying dark channel estimation, the atmospheric light estimation and transient estimation algorithms are applied to calculate variations as shown in figure 10. Figure10 is the dehazed image of the object obtained after further optimization by smoothening the transient image figure11.

Figure 10 Radiant Image after haze removal

The estimation of pixel value in dark region and the atmospheric variation estimation are the estimation of transmission obtained as shown in transient image figure10.The final output is a transient image after haze removal.

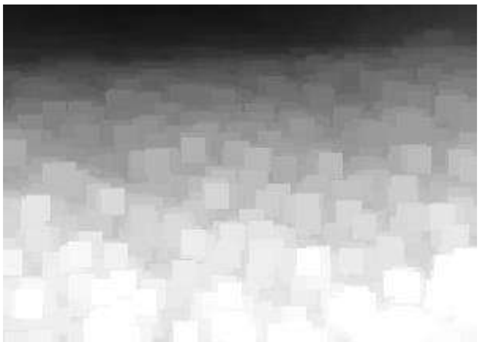

Figure 11 Transient Image after haze removal

Table 1 Result Analysis

S.No.	Parameter	LBVR	EDCPF
1.	Time Complexity	5.25 sec.	2.1 sec.
2.	Quality Factor (PSNR)	35.89dB	38Db

In figure 12 , time is represented in Y-axis while Techniues Laplacian Based Visibility Restoration (LBVR) appraocah and Enhanced DCP filter appraoch are to be depicted in X-axis. It is obsereved from the Time complex grah that time taken by newly developed approach (EDCPF) is very less as compare to time taken by earlier

ISSN: 2321-8169
191 – 196

appraoch(LBVR). It means that EDCPF is fruitful for hazy image.

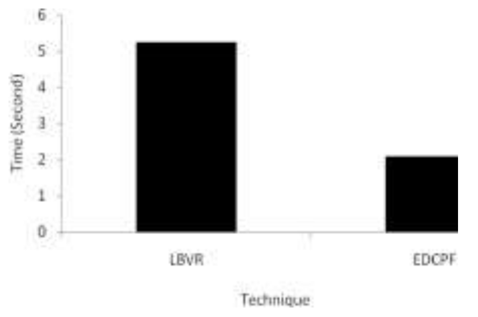

Fig 12 Time Complexity Graph

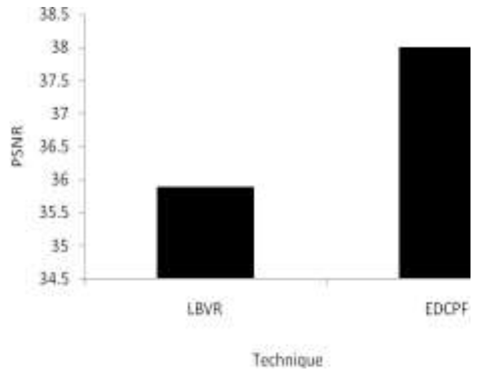

Figure 13 Quality Graph

The above figure 13 shows a Quality factor graph. Here, quality in dB is to be displayed in Y axis. Techniques LBVR and EDCPF are to be considered in X axis. The graph has been drawn between Quality (dB) and LBVR, EDCPF. The Quality is depicted in term of PSNR (pixel to noise ratio). The Quality of newly developed approach ECPF is good as compare to earlier approach (LBVR). It seems that quality of image is good because the no of pixels are more.

V Conclusion

A haze removal technique (EDCP) is combination of an edge-preserving decomposition technique to estimate the transmission map for a haze image and DCP. Another author worked (IVR formula) is applicable to haze pictures, underwater pictures, and traditional pictures. The combination of edge-preserving decomposition and DCP is for quality output. The image after haze removal is obtained with the respective running time as given in table 1. The high quality haze free image is also obtained. It is depicted in figures 12 and 13 that the time complexity of the Enhanced DCP filter is low as compare to Laplacian based visibility restoration approach as well as the quality factor of the Enhanced DCP filter is better as compared to the quality of Laplacian based visibility restoration approach.

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