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# Edge Preserving Decomposition-Based Haze Removal in Video Sequence Using Koschmiedars Law

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***Abstract:*** **In this paper, we will give the input as video and will divide it into different frames. Here, a novel edge-preserving decomposition based method is introduced to find out the transmission map for a haze image, so as to design a video haze removal algorithm from the Koschmiedars law without using any prior.**
***Keywords:*** **Video haze removal, edge preserving smoothing, weighted guided image filtering.**

## I. INTRODUCTION

Image processing is a widely using area and it has many applications. In imaging science, image processing is processing of images using the mathematical operations by using any form of signal processing for which the input is an image, a series of image, or a video, such as a photograph or video frame.

Clarity of outdoor images is affected due to poor weather, such as haze, fog, sandstorms etc. This is due to the presence of many atmospheric particles that absorb and scatter light between the camera and the captured video. It can cause different problems to the systems like obstacle detection systems, video surveillance systems etc. Due these problems haze removal is highly demanded in image processing.

The amount of scattering depends on the unknown distances of the scene points from the camera as well as the air-light is also not known. Therefore it is challenging to remove haze from a video.

Many methods were presented to remove the haze from the single image as well as multiple images. But this is the first paper which deals with removing the haze from a video. For example, in [1], the depth boundary is detected from multiple images captured under various atmospheric or weather conditions, and a haze free image is then recovered. The haze is removed by using a polarization based method in [2] through two images taken with the different degrees of polarization. Although these methods work well in the presence of multiple images capturing the same scene with haze, applications of these methods are limited because of their requirements on the inputs. Later, many single image haze removal algorithms were proposed.

Based on an observation that a haze-free image has higher contrast than its haze image, an interesting single image haze removal algorithm was proposed in [4] by maximizing the local contrast of the restored image. The algorithm proposed by Fattal [5] sounds reasonable from the physical point of view and it can also produce impressive results. But, this algorithm may fail in the presence of heavy haze. The dark channel prior was simplified in [6] and [7] by using the minimal color component of a haze image. Other than the above haze removal algorithms, many other interesting single image haze removal algorithms were recently proposed such as [9], [10],[15],[8], and [2]. But there is no video haze removal algorithm from the Koschmiedars law without using any prior. The proposed paper is better in performance than the previous papers as shown in the figure 2. Here we will divide the video into many frames and will apply a novel edge preserving decomposition method to find out the transmission map.

## II. CONVERTING VIDEO AS FRAMES

In this paper we are giving the input as video. We know that video is a collection of different number of frames. While giving the input, the video is read by using the code video reader. Each frame is read one after the other and will find the total number of frames present in the video. After reading every frame, it is written by using the code video writer.

## III. EDGE PRESERVING DECOMPOSITION OF HAZE IMAGE

In this section, a new model is built up to decompose the simplified dark channel of the haze image into two layers. ie, the base layer and the detail layer.

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A. Haze Image Modeling.

According to the Koschmiedars law [11], a haze image is generally represented by:

$$X_c(p)= Z_c(p)t(p) + A_c(1-t(p)), \qquad (1)$$

where $c \in \{r, g, b\}$ is a color channel index, $X_c$ is a haze image, $Z_c$ is a haze-free image, $A_c$ is the global atmospheric light, and t is the medium transmission describing the portion of the light that is not scattered and reaches the camera.

When the atmosphere is homogenous, the transmission t(p) can be expressed as:

$t(p)=e-ad(p)$, (2)

Where α is the scattering coefficient of the atmosphere. It indicates that the scene radiance is attenuated exponentially with the scene depth d (p). The value of α is a monotonically increasing function of the haze degree.The objective of haze removal is to restore the haze- free image Z from the haze image X. It is a challenging problem because the haze is dependent on the unknown depth information d(p) as in Equation (2).Also, it is under constrained as the input is only a video while all the components $A_c$, t(p) and $Z_c$ (p) are freedoms. To restore the haze-free image Z, both the global atmospheric light Ac and the transmission map t(p) is need to be calculated. The haze- free image Z is then restored as:

$Z_c(p)= X_c(p)+( 1\ t(p) -1)(X_c(p)- A_c)$, (3)

From the above equation it is clear that single image haze removal is a type of spatially varying detail enhancement. The amplification factor is (1 t(p)−1) which is spatially varying, and the detail layer is ($X_c$ (p) − $A_c$) [6].

B. Simplified Dark Channel Decomposition of a Haze Image

A new haze image model is derived by using the simplified dark channels of the haze image X and the haze-free image Z. Let Am, $X_m$ (p) and $Z_m$ (p) be defined as [6].

$A_m = \min\{A_r, A_g, A_b\}$, (4)

$X_m(p) = \min\{Xr(p), X_g(p), X_b(p)\}$, (5)

$Z_m(p) = \min\{Z_r(p), Z_g(p), Z_b(p)\}$. (6)

$X_m$ and $Z_m$ are called the minimal color components of the images X and Z, respectively [7]. Because the transmission map t(p) is independent of the color channels r, g, and b, it can be derived from the haze image model in Equation (1) and the relationship between the minimal color components $X_m$ and $Z_m$ is given as:

$A_m - X_m(p)$ (7)

$A_m - X_m(p)=(A_m - Z_m(p))t(p)$, (8)

## IV. Single Image Haze Removal Using Edge Preserving Decomposition

In this section, a simple single image algorithm for haze removal is introduced. The global atmospheric light Ac(c ∈{ r, g, b}) is first determined by using a hierarchical searching method. The WGIF is then used to decompose the simplified dark channel of a haze image into two different layers as in Equation (8) and the value of t(p) is then obtained. Finally, the scene radiance Z(p) is obtained by using the haze image model as in Equation (1).

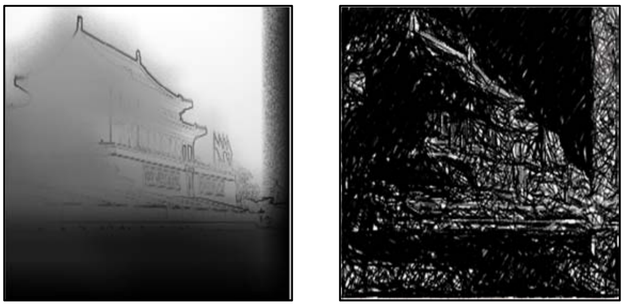
**4.**

A. Empirical Estimation of the Global Atmospheric Light

The global atmospheric light Ac(c ∈{r, g, b}) is usually estimated as the brightest color in a hazed image X, since a large amount of haze causes a bright color. But, objects which are brighter than the atmospheric light, could lead to undesirable selection of the atmospheric light. Based on the observations that the variance values of pixels are generally small while the intensity values are large in bright regions, the values of Ac(c ∈{ r, g, b}) are obtained by a hierarchical searching method on basis of the quad-tree subdivision [12].

At first the input image is divided into four rectangular regions and the each region is assigned a value which is computed as the average pixel value subtracted by the standard deviation of the pixel values within the region. The region with the highest value is then selected and it is furthered divided into four smaller rectangular regions.

The process is continued until the size of the selected region is smaller than a predefined threshold which is selected as 32×32 if it is not specified. In the final selected region, the pixel which minimizes the difference ‖ (Xr(p), Xg(p), Xb(p))−(255,255,255) ‖ is chosen and it is used to determine the global atmospheric light Ac.



(a) (b)

**Fig 1: Minimal color component and simplified dark channel of the haze image in Fig. 1(a). The minimal color component (a) preserves the structure of the haze image better than the simplified dark channel (b).**

B. Estimation of the Transmission Map

Once the values of Ac(c ∈{r, g, b}) are obtained, then the value of $A_m$ can be computed by using Equation (4). The decomposition model in Equation (8) is available. The WGIF in [5] is applied to decompose the image (Am− $J^X$d (p)) into two layers as in Equation (8) and shown in the figure 1. The guidance image G is computed using the minimal color channel $X_m$ rather than the simplified dark channel $J^X$d as:

$G(p)= A_m - X_m(p)$. (9)

This is because the structure of the haze image is better preserved by the minimal color component $X_m$ than the simplified dark channel $J^X$d . It is assumed that the base layer t(p) is a linear transform of the guidance image G(p) in the window Ωζ1(p′):

$t(p)= a_{p'}G(p)+\breve{b}_{p'}\ \forall p \in \zeta 1(p)$, (10) Where $a_{p'}$ and $\tilde{b}_{p'}$ are two constants in the window $\Omega_{\zeta 1}(p')$. The values of $a_{p'}$ and $\tilde{b}_{p'}$ are obtained by minimizing the following cost function $E(a_{p'}, \tilde{b}_{p'})$:

$$\sum_{p\in\Omega_{\zeta 1}(p)}[(a_{p'} G(p) + \tilde{b}_{p'} - (A - J Xd (p')))^2 + (\lambda / \Gamma G(p') a^2_{p'})] \quad (11)$$

Where the values of $\zeta 1$ and $\lambda$ are respectively set at 60 and 256 if they are not specified. It should be mentioned that an optimization based approach was proposed in [13] and [14]. Both the approach in [13] and [14] and the proposed one assume that the global atmospheric light is empirically determined in advance.

Two major differences between the approach in [13] and [14] and the proposed one are: 1) the approach in [13] and [14] is based on global optimization while the proposed one is based on local optimization; and 2) the proposed approach is explicitly based on edge preserving smoothing techniques while the approach in [13] and [14] is not. And the proposed algorithm is simpler than the approach in [13] and [14].

Defining $\phi(p)$ as $(A_m - t(p))$ and $b_{p'}$ as $((1- a_{p'})A_m - \tilde{b}_{p'})$, it can be derived that

$$\phi(p)= a_{p'} X_m (p)+ \tilde{b}_{p'} ; \Gamma G(p')= \Gamma X_m (p'), \quad (12)$$

The optimal solution $\phi*(p)$ is then given as follows:

$$\phi^*(p)=\bar{a}^*_p X_m (p)+\bar{b}^*_p, \quad (13)$$

Where $\bar{a}^*_p$ and $\bar{b}^*_p$, are the mean values of $a^*_p$ and $b^*_p$ in the window $\Omega_{\zeta 1}(p)$, respectively. The optimal value of the transmission map t(p) is calculated as:

$$t^*(p)= 1-( \phi^*(p)/ Am). \quad (14)$$

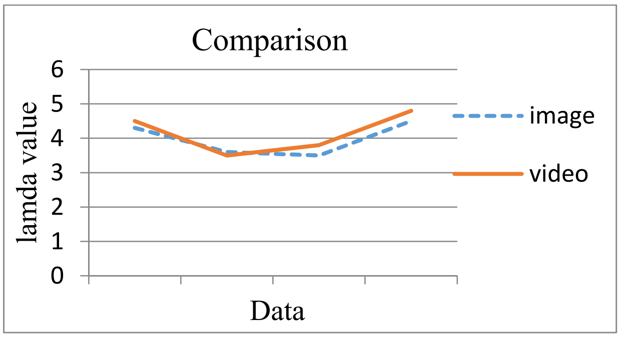



**Fig 2: Performance analysis between the two samples based on the lamda value.**

C. Recovery of the Scene Radiance

Once the values of the global atmospheric light Ac($c \in \{r, g, b\}$) and the transmission map t(p) are calculated, then the scene radiance Z(p) is recovered by:

$$Z_c (p) = (1/ t^* (p)) (X_c(p)- Ac) + Ac. \quad (15)$$

Consider the case that the input image $X_c(p)$ includes noise, i.e.,

$$X_c(p)= \hat{X}_c (p) + e_c (p), \quad (16)$$

Where $e_c(p)$ is the noise. Equation (15) is equivalent to:

$$Z_c (p)= (1/t^* (p)) (\hat{X}_c (p)- A_c)+ A_c + (1/t^*(p)) e_c (p). \quad (17)$$

It is shown that the value of $t^*(p)$ is always less than or equal to 1. The value of $t^*(p)$ approaches 0 if the pixel p belongs to a sky region Clearly, the value of $1/ t^*(p)$ is very large if the pixel p belongs to a sky region.

## V. Limitation Of The Proposed Algorithm

(a) (b)

**Fig 3: Limitation of the proposed haze removal algorithm. (a) a hazed image; and (b) a dehazed image by the proposed algorithm.**

One possible problem for the proposed algorithm is that the estimation of haze level is not accurate as shown in the figure 3. Clearly, the haze is not removed well. The problem could be solved by introducing an interactive mode to the proposed algorithm which allows a user to removal haze according to her/his preference.

## VI. Conclusion

A video haze removal algorithm has been proposed in this paper by dividing the video into different frames and then by introducing an edge-preserving decomposition technique to estimate the transmission map for a haze image. The proposed algorithm is a new framework for video haze removal which is from the Koschmiedars law without using any prior.

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