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Fog Removal Based On Local Extrema

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Abstract: Atmospheric conditions induced by suspended particles,such as fog and haze, severely alter the scene appearance.In this paper, we propose a novel defogging method basedon the local extrema, aiming at improving the image visibilityunder foggy or hazy weather condition. The proposed methodutilizes atmospheric scattering model to realize the fog removal.It applies the local extrema method to figure out three pyramidlevels to estimate atmospheric veil, and manipulates the toneand contrast of details at different scales through multi-scaletone manipulation algorithm. The results on the experimentsof comparison with traditional methods demonstrate that theproposed method can achieve more accurate restoration for thecolor and details, resulting in a great improvement in imagevisibility.

Keywords:Defog, local extrema, atmospheric scattering model, haze removal.

I. INTRODUCTION

Poor visibility becomes a major problem for most outdoor vision applications. Bad weather, such as fog andhaze, can significantly degrade the visibility of a scene. Thelow visibility inevitably handicaps visual recognition and comprehension. The goal of defogging methods is to removethe effects of fog and recover details and colors of scene fromfoggy image.

Most traditional image enhancement methods, such as histogram equalization, Retinex, the wavelet transform, usuallycannot obtain ideal defogging result. These methods mainly focus on enhancing low brightness and low contrast features in digital images, and they are simple, efficient, and can be applied to most real-time scenes. However, they do not consider the reason why the image is degraded by fog and cannot compensate effectively. Therefore, these methods are limited to perform the defogging task and even may introduce halo artifacts or distort the color.

II. BACKGROUND

The attenuation of luminance through the atmosphere was studied by Nayar and Narasimhan, who derived a foggy image degradation model called atmospheric scattering model. This model relates the apparent luminance $I(x;y)$ of an object located at distance $d(x;y)$ to the luminance $R(x;y)$ measuredclose to this object:

$$I(x;y) = R(x;y)\, e^{¡¯d(x;y)} + A1 ¡ e^{¡¯d(x;y)}; \quad (1)$$

;where $d(x;y)$ is the distance of the object at pixel $(x;y)$, A is called skylight and represents the luminance of the sky, is the scattering coefficient of the atmosphere, $I(x;y)$ is the intensity of image degraded by fog. $R(x;y)$ is the intensity of clear image without fog. The removal of the fog is actually to solve $R(x;y)$. The atmospheric scattering model assumesthat the atmosphere is homogeneous and does not consider wavelength's influence on atmospheric scattering coefficient,so ¯ is considered to be a constant. The difficulty is that single image defogging is an ill-posed problem. Indeed, from (1),defogging requires to estimate A, ¯ and d at every pixel, onlyknowing the input image I.

In the atmospheric scattering model, the calculation of scenedepth and atmospheric scattering coefficient generally requires additional information such as the vanishing points from theinfinite plane. The location confirmation of vanishing pointsrelies on the subjective judgment or is realized through the image processing algorithm (e.g.,Hough transform, Curvelet transform). In many cases, vanishing points are difficult to be accurately estimated, which may cause the bad image visibility restoration. As a consequence, we introduce the atmospheric veil to avoid solving d and ¯, which can be expressed by

$$V(x;y) = A(1 ¡ t(x;y)); \quad (2)$$

where V is defined as the atmospheric veil, t is the transmissionmap which can be expressed as $t(x;y) = e^{¡¯d(x;y)}$.V denotes the effect of ambient light[1], t reflects the ability of light penetration. They both contain the depth information.Estimating the transmission map and atmospheric veil are two main kinds of defogging method based on the physical model.The estimation of t needs to rely on solution of skylight anda constant parameter setting[6], however, estimation of V canavoid being directly influenced by other parameters and can be executed quickly and accurately. Through the subsequent parameter adjustment, estimating atmospheric veil method canachieve good image restoration result.

III. DEFOGGING METHOD

In this paper, we introduce a novel defogging technique based on local extrema method to remove fog or haze froma single image. Our method can be decomposed into

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threesteps: estimating the skylight and correcting color throughwhite balance; estimating the atmospheric veil based on localextrema method and recovering the image visibility by invertingatmospheric scattering model; Controlling the visibility bymulti-scale tone manipulation algorithm

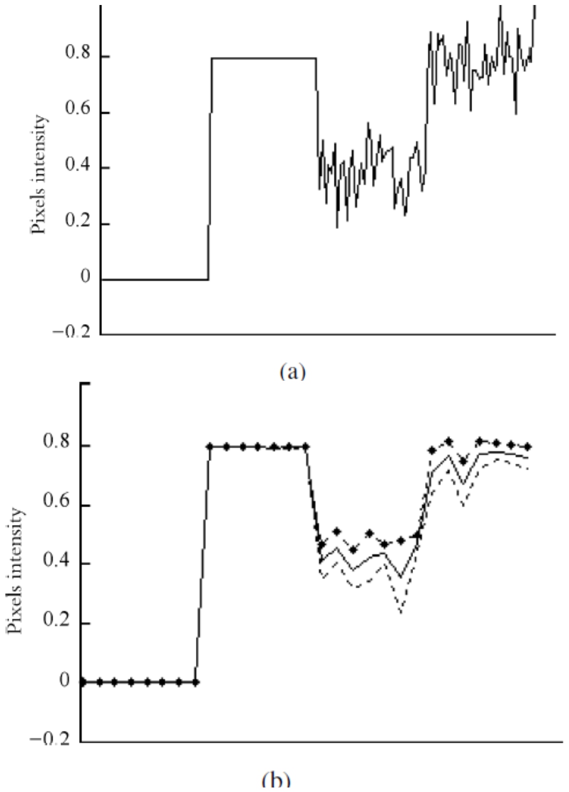


Fig. 1. Image smoothing effect in three scales. (a)The input image signal (b)The smoothed results by the minimal envelope(dash line),maximal envelope(dot-dash line) and the mean layer (continuous curve) computed by these two envelopes**.**

IV.COMPARISON EXPERIMENTS

In order to verify the effectiveness of the defogging method,we will evaluate the proposed method on the real scene and the virtual scene. The experiments will be conducted on the matlab platform and mainly deal with low resolution images for better detail comparison. Firstly, in the aspect of restoring real worldfoggy images, our method will compare with two classical methods: Tarel*0*s noblack-pixel constraint (NBPC) and He*0*s method based on guided filter. Tarel et al. introduced a complete inference of atmospheric veil in . He et al first proposed dark channel prior to initialize transmission estimation in However, the matting Laplacian regularization might lead to an overall reduction of contrast at the distant regions and had high time and space complexity. Reference was their improved method free from these problems.Both methods are known for their robustness and can produce visually pleasing restored results. The time consumption of is mainly associated with the estimation of transmission map or atmospheric veil. Both of their calculations can reach O(N). From top to bottom, the dimensions of images provided in Fig. 3 are 315£315, 460£380, 600£400 and 600£450,and the four groups of experimental images are expressed as Fig. 3(a)»(d)

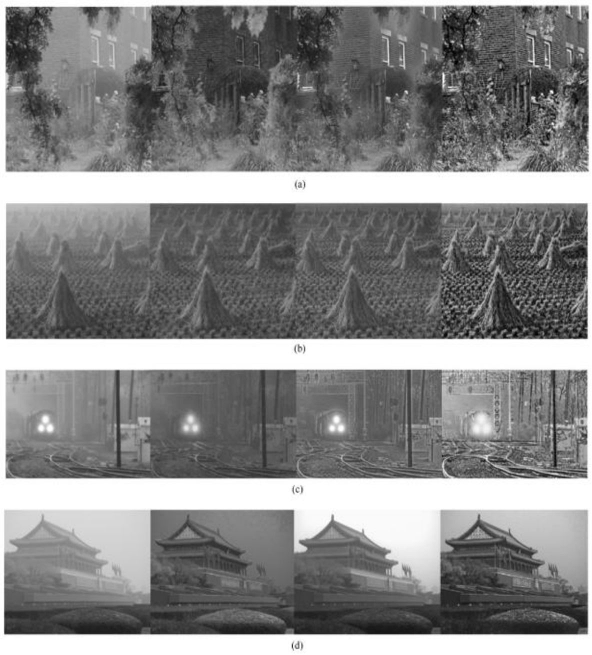
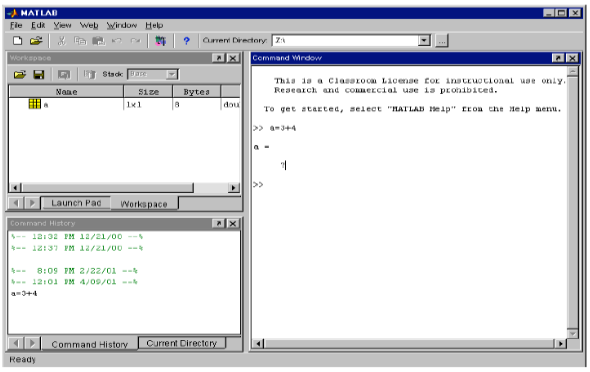


Fig. 3. Fog removal results of real world image. From left to right: the input foggy images, Tarel*0*s results, He*0*s results, and our results

V.USING MATLAB

The fog removal conversion is achieved through the Matlab software. To prove the robustness of our method, the new operator has been tested on a large dataset of different natural hazy images. Haze due to dust, smoke and other dry particles reduces visibility for distant regions by causing a distinctive gray hue in the captured images..

A. Command Window



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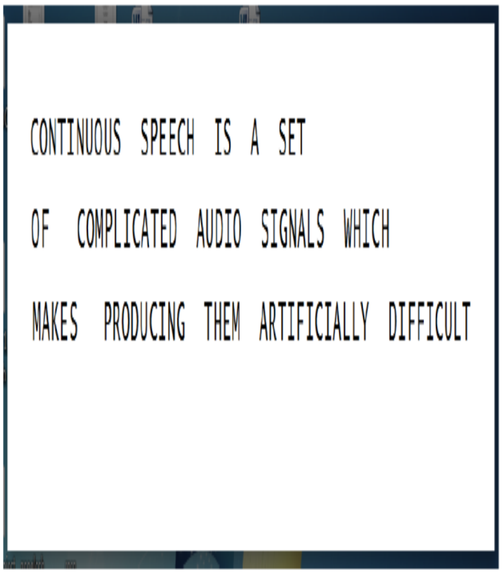
B. INPUT IMAGE



V1.SIMULATION AND RESULT

The Text To Speech conversion is achieved through the Matlab software. However, our technique has been successfully tested as well for a slightly different case: foggy scenes. For our problem, fog has a similar impact as haze, but technically it appears as a dense cloud of water droplets close to the ground when night conditions are clear but cold, and the heat released by the ground is absorbed during the day. We assume that the input hazy/foggy images are color images and the images may contain achromatic objects

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BIOGRAPHY

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