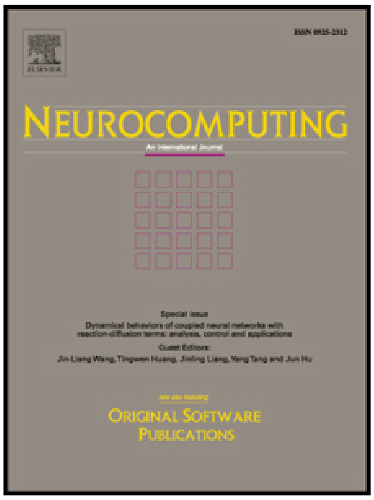

Single Image Haze Removal Based on the Improved Atmospheric Scattering Model

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Single Image Haze Removal Based on the Improved Atmospheric Scattering Model

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Abstract: In this paper, we propose an improved atmospheric scattering model (IASM) to overcome the inherent limitation of the traditional atmospheric scattering model. Based on the IASM, a fast single image dehazing algorithm is also presented. In this algorithm, by constructing a linear model between the transmission and the haze aware density feature, the transmission map can be directly estimated through a linear operation on three components: luminance, saturation and gradient. Combining the sky-relevant feature and the proposed guided energy model (GEM), we can accurately estimate the atmospheric light and scene incident light, and can further restore the scene albedo via the IASM. Finally, an accelerating framework (AF) based on the Gaussian-Laplacian pyramid is proposed to increase the computational speed. Experimental results demonstrate that the proposed algorithm outperforms most of the prevalent algorithms in terms of visual effect and computational efficiency. Besides, it is also capable of processing various types of degraded images in addition to hazy images.

Keywords: Improved Atmospheric Scattering Model, Linear Model, Gaussian-Laplacian Pyramid, Image Haze Removal, Haze Aware Density Feature

1、Introduction

In bad weather (e.g., foggy or hazy), due to the influence from the suspended particles in the atmosphere, outdoor images are susceptible to yield poor visibility, such as reduced contrast and faint color (see Fig. 1(a)). Using these degraded images as input may cause catastrophic errors in many computer vision systems. Consequently, developing a haze removal technique is of practical significance for many computer vision applications [1] [2].

Currently, the algorithms for haze removal are classified into four classes: contrast stretching algorithms [3-5], multi-scale fusion algorithms [6] [7], Retinex dehazing algorithms [8] and physics-based algorithms [9-31]. Generally, physics-based dehazing algorithms are able to achieve better performance than others types of algorithms because they take the degradation mechanism into consideration and restore a haze-free image via strong prior knowledge. However, physics-based algorithms still have their own limitation. For example, Tan [9] removed haze by maximizing the local contrast of the restored image. Nevertheless, it performed contrast stretching in essence, and thus, the restored results usually tend to be over-saturated. Nishino [10] adopted the Bayesian posterior probability model to remove haze, in which the latent statistical structure was fully leveraged. Although the method works well in dense haze, it may produce over-enhanced output in case of mist. Fattal [11] assumed that the transmission and chroma in the local patch are uncorrelated and removed the haze based on the color statistics, but this algorithm would be invalid for regions that lack distinctive color features. Fattal [12] also derived a local formation model that explains the color-lines in the context of hazy scenes and use it for recovering the transmission. However, this method cannot be applied to the mono-color images where the notion of color-lines trivializes, and may fail in some specific cases (such as the images with many artificial colored lines and specular highlights, as discussed in [12]). Tarel [13] estimated the atmospheric veil using the median filter. Owing to the poor performance of the median filter for edge preserving, a small amount of mist would remain around the depth jumps. He [14] discovered the dark channel prior (DCP), that is, for most of the non-sky patches, at least one color channel contains one pixel whose intensity is close to zero. With this prior, the transmission map can be directly estimated, and further restore the haze-free image via the atmospheric scattering model. Although the DCP is effective in most cases, it cannot well handle the regions whose brightness is inherently similar to the atmospheric light. On the other hand, the dehazing procedure is time consuming due to the high computational complexity of the soft matting [15]. To overcome these problems, some improved methods [16-18] are proposed to address the invalid problem of the DCP for the bright regions. And other optimization methods [19-25] are proposed to replace the time-consuming soft matting, which is aimed at increasing the computational efficiency.