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A fast image dehazing algorithm based on negative correction

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A B S T R A C T

Dehazing is an important but difficult issue for image processing. Recently, many dehazing algorithms have been proposed based on the dark channel prior. However, these algorithms fail to achieve a good tradeoff between the dehazing performance and the computational complexity. Moreover, the perceptual quality of these algorithms can be further improved, especially for sky areas. Therefore, this paper firstly introduces the concept of negative correction inspired by the practical application of photographic developing and a fast image dehazing algorithm is accordingly proposed. Based on the observation of the photographic developing, we find that the contrast of images can be enlarged and their saturation can also be increased when their negative images (or reverse image) are rectified. Thus, instead of estimating the transmission map, the correction factor of negative is estimated and it is used to rectify the corresponding haze images. In order to suppress halos, a modified maximum-filter is proposed to limit the larger value of correction factor of local region. The experimental results demonstrate that the proposed algorithm can effectively remove hazes and maintain the naturalness of images. Moreover, the proposed algorithm can significantly reduce the computational complexity by 56.14% on average when compared with the state-of-the-art.

1. Introduction

Image restoration and enhancement is a classical research area but is still a hot topic. There are many reasons for image quality decline. Therefore, a lot of specialized methods [1–5] are proposed to improve image quality. One source of the reasons is the presence of haze. Haze is caused by suspended particles or water droplets in the atmosphere. The visibility of the scene is degraded due to a series of reactions, such as scattering, refraction, and absorption between these particles or water droplets and light from the atmosphere. With lowered contrast and faded color, the degraded dull images lose their visual vividness and appeal.

Image dehazing is an important issue in many scene understanding applications such as surveillance systems, intelligent vehicles, satellite imaging, aerial imagery [6], or target identification and feature extraction in a reliable fashion. However, image dehazing remains a challenge due to the unknown scene depth information. According to the previous research, the conventional contrast enhancement algorithms, such as the histogram stretching and equalization, the linear mapping, and the gamma correction, fail to achieve an appropriate result and will introduce color distortion, which cannot meet the requirement of practical applications [7].

Since the amount of scattering is a function of the distance, the degradation is spatial variant. In order to extract depth information for image dehazing, researchers focused on image dehazing by using additional information [8,9] or

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multiple images [10–15]. Recently, many single image haze removal algorithms [16–22] have been proposed by using reasonable priors/assumptions [23–25] and the widely-used haze imaging model proposed in Refs. [13,14].

Tan et al. [23] proposed to maximize the local contrast of an input image to improve the image visibility, due to the observation that haze-free images (or enhanced images) have higher contrast than images plagued by bad weather. However, although the perceptual quality can be improved, the enhanced images fail to maintain the original color. Since haze-free images do not always have the maximum contrast, this algorithm may easily lead to image color over-saturation and distortion. The above conclusion can be observed from Fig. 1(b), wherein there is

Fig. 1. The technique limitation of the current dehazing algorithms. ((b) is from He's project page: http://research.microsoft.com/en-us/um/people/kahe/cvpr09/comparisons.html; (e) is from Fattal's project page: http://www.cs.huji.ac.il/~raananf/projects/defog/). (a) Original image, (b) Tan result [18], (c) Our result, (d) Original image, (e) Fattal result [24], (f) Our result, (g) Original image, (h) DCP result [25], (i) Our result, (j) Original image, (k) GDCP result [20], and (l) Our result.