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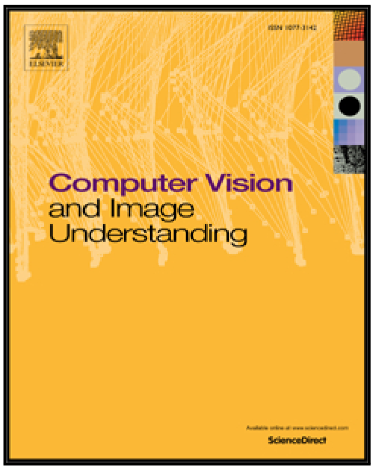

Haze Visibility Enhancement: A Survey and Quantitative Benchmarking

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Haze Visibility Enhancement: A Survey and Quantitative Benchmarking

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Abstract

This paper provides a comprehensive survey of methods dealing with visibility enhancement of images taken in hazy or foggy scenes. The survey begins with discussing the optical models of atmospheric scattering media and image formation. This is followed by a survey of existing methods, which are categorized into: multiple image methods, polarizing filter-based methods, methods with known depth, and single-image methods. We also provide a benchmark of a number of well-known single-image methods, based on a recent dataset provided by Fattal [1] and our newly generated scattering media dataset that contains ground truth images for quantitative evaluation. To our knowledge, this is the first benchmark using numerical metrics to evaluate dehazing techniques. This benchmark allows us to objectively compare the results of existing methods and to better identify the strengths and limitations of each method.

Keywords: Scattering media, visibility enhancement, dehazing, defogging

1. Introduction

Fog and haze are two of the most common real-world phenomena caused by atmospheric particles. Images captured in foggy and hazy scenes suffer from noticeable degradation of visibility and significant reduction of contrast, as shown in Figure 1. To visually recover scenes from haze or fog can be critical for image processing and computer vision algorithms. Haze-free photographs with clear visual content are what consumers desired when shooting target objects or landscapes; hence, cameras or image-editing softwares that can recover scenes from haze or fog are useful for consumer markets. In addition, many computer vision systems, particularly those for outdoor scenes (e.g., surveillance, intelligent vehicle systems, remote sensing systems), assume clear scenes under good weather. This is because the underlying algorithms, such as object detection, tracking, segmentation, optical flow, obstruction detection, stereo vision are designed with such an assumption. However, mist, fog, and haze are natural phenomena that are inevitable and thus have to be resolved.

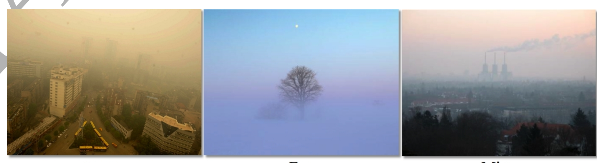

Figure 1: Several examples of images showing the visual phenomena of atmospheric particles. Most of them exhibit significant visibility degradation.

Therefore, addressing this problem is of practical importance.

The degradation in hazy and foggy images can be physically attributed to floating particles in the atmosphere that absorb and scatter light in the environment [2]. This scattering and absorption reduce the direct transmission from the scene to the camera and add another layer of the scattered light, known as airlight [3]. The attenuated direct transmission causes the intensity from the scene to be weaker, while the airlight causes the appearance of the scene to be washed out.

In the past two decades, there has been significant progress in methods that use images taken in hazy scenes. Early work by Cozman and Krotkov [4] and Nayar and Narasimhan [5, 6] uses atmospheric cues to estimate depth. Since then, a number of methods

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