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IMAGE DEHAZING TO ENHANCE IMAGE QUALITY USING DCP AND GUIDED FILTER BASED HYBRID ALGORITHM

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Abstract: Image dehazing is a critical task in computer vision and image processing that aims to restore clear visibility in hazy or foggy images. In recent years, significant advancements have been made in image dehazing algorithms, leading to improved results and enhanced visual quality. This paper presents a comprehensive review and comparative analysis of state-of-the-art image dehazing techniques. We categorize the existing methods into different groups based on their underlying principles and analyze their strengths and limitations. Additionally, we provide a comparative evaluation of these techniques based on various metrics, including visual quality, computational complexity, and robustness to different hazing conditions. This analysis aims to assist researchers and practitioners in understanding the current landscape of image dehazing methods and identifying avenues for future research.

Keywords: Image dehazing, computer vision, image processing, visibility restoration, hazy images, foggy images.

INTRODUCTION

Image dehazing is a fundamental task in computer vision and image processing, aiming to restore visibility and enhance the quality of images captured under hazy and foggy conditions. The presence of atmospheric haze significantly degrades visual content, resulting in reduced contrast, color distortion, and loss of fine details. Over the years, numerous image dehazing methods have been proposed, each addressing the challenge of haze removal with varying degrees of success. Among the many techniques, the Dark Channel Prior (DCP) has emerged as a powerful and widely recognized approach for single-image dehazing. Introduced by He et al. in 2011, the DCP exploits the observation that the minimum intensity value of a hazy image's local patch, known as the dark channel, tends to be a good indicator of haze presence. By leveraging the dark channel, the DCP effectively estimates the transmission map, a critical parameter for dehazing, and subsequently enhances the visibility of the scene.

In this paper, we present a comprehensive survey of image dehazing techniques based on the Dark Channel Prior. Our objective is to provide readers with a detailed understanding of the principles, strengths, and limitations of these methods. We categorize the surveyed techniques into distinct groups based on their advancements, and we analyze the developments made in this field over the past decade, from 2010 to 2021. By focusing on the DCP-based approaches, we aim to shed light on the current state-of-the-art in image dehazing and inspire future research in this vital domain.

The remainder of this paper is organized as follows: In Section 2, we delve into the fundamental concepts of the Dark Channel Prior and its role in single-image dehazing. Section 3 provides an in-depth review of the various DCP-based dehazing techniques, highlighting their unique characteristics and contributions. In Section 4, we present a comparative analysis of the surveyed methods, evaluating their performance across different evaluation metrics. Challenges and open problems in image dehazing using the DCP are discussed in Section 5, while Section 6 concludes the paper with a summary of key findings and future research directions.

In summary, this survey serves as a comprehensive resource for researchers, practitioners, and enthusiasts interested in image dehazing techniques based on the Dark Channel Prior. By understanding the strengths and limitations of these methods, we aspire to accelerate advancements in dehazing algorithms, ultimately contributing to enhanced visual quality and improved performance across various applications, such as autonomous driving, surveillance, and remote sensing.

II.DARK CHANNEL PRIOR METHOD

The Dark Channel Prior (DCP) is a fundamental concept in image dehazing that forms the basis of numerous dehazing algorithms. Introduced by He et al. in 2011, the DCP exploits the statistical properties of outdoor natural scenes to estimate the transmission map, which is crucial for dehazing single hazy images.

a)Principle of Dark Channel Prior

The DCP relies on the observation that most local patches in a hazy image contain some pixels with very low intensity values, often referred to as "dark pixels." These dark pixels correspond to regions that are not affected by haze and exhibit strong intensity contrast in the local patch. The underlying principle of the DCP is that the minimum value of the intensity channel among these dark pixels, known as the "dark channel," tends to be very close to zero for non-hazy regions. This forms the foundation of the DCP's effectiveness as a haze indicator.

b) Estimating Atmospheric Light

One of the key steps in using the DCP for image dehazing is estimating the atmospheric light. The atmospheric light represents the intensity of the scene when there is no haze present. Typically, the atmospheric light is computed as the maximum intensity value in the hazy image, assuming that the brightest pixels correspond to non-hazy regions or regions affected minimally by haze.

c) Transmission Map Estimation

Once the atmospheric light is estimated, the next step is to calculate the transmission map. The transmission map represents the degree of haziness at each pixel in the image. In the DCP approach, the transmission map is estimated using the following equation:

$$r(u) = 1 - \omega \times cmin \in (r,g,b) \min y \in \Omega(u)\ Jc(y)qc \qquad 1.$$

where r(u) is the transmission value at pixel u, ω represents a local patch centered at pixel u c(y) denotes the intensity value of color channel c at pixel y and Jc represents the estimated atmospheric light value for color channel. The parameter is a Ω constant that controls the strength of the haze removal.

d) Haze Removal

With the transmission map estimated, the final step is to remove the haze from the image. The haze-free image is obtained using the following equation:

$$F(u) = F(u) - Qmax\ (t(u), t0) + Q$$

F(u) is the dehazed pixel value.

e) Limitations of the Dark Channel Prior

While the Dark Channel Prior has demonstrated remarkable success in various image dehazing scenarios, it is not without limitations. One significant challenge is handling scenes with heterogeneous haze, where the assumptions of the DCP may not hold uniformly. Moreover, the DCP-based methods may exhibit artifacts and color inconsistencies in some cases, especially when the haze is severe or when there are abrupt changes in the scene's lighting conditions.

Despite these limitations, the Dark Channel Prior remains a powerful and widely used approach in the field of image dehazing, providing a solid foundation for further advancements in haze removal techniques.

In the subsequent sections, we will explore various DCP-based image dehazing techniques and evaluate their performance in detail, shedding light on their strengths and weaknesses in different scenarios.

III. LITERATURE REVIEW

In this section, we review and analyze various image dehazing techniques that are built upon the Dark Channel Prior (DCP) framework. Over the past decade, researchers have made significant advancements in exploiting the DCP to address the challenges posed by haze in images. These methods can be broadly categorized into the following sub-sections:

1)Single-Image Dehazing Techniques

Single-image dehazing techniques aim to restore visibility in hazy images using only the information present in a single input image. Several innovative methods have been proposed in this category, each offering unique strategies to estimate the transmission map and enhance dehazing results. Some notable approaches include:

1a. Dark Channel Prior with Atmospheric Light Refinement

This approach focuses on improving the accuracy of atmospheric light estimation, which is crucial for precise transmission map computation. By incorporating scene-specific information, such as horizon lines or scene geometry, these methods enhance the reliability of the atmospheric light estimation, leading to improved dehazing performance [1].

1b. Fusion with Depth Information

Some techniques leverage depth information to enhance single-image dehazing. By combining depth maps with the DCP, these methods achieve better scene understanding and address challenges related to scene structure, depth variations, and haze distribution [2].

1c. Learning-Based Approaches

Recent advancements in deep learning have significantly impacted image dehazing. Learning-based methods use Convolutional Neural Networks (CNNs) and Generative Adversarial Networks (GANs) to directly learn the mapping from hazy images to their corresponding haze-free versions. These techniques demonstrate promising dehazing results by effectively modeling complex haze characteristics [3].

2) Multi-Image Dehazing Techniques

Multi-image dehazing techniques exploit information from multiple input images, such as stereo pairs, time-of-flight (ToF) data, or polarization-based images. By leveraging diverse data sources, these methods aim to enhance the robustness and accuracy of the dehazing process. Notable techniques in this category include:

2a. Stereo-Based Dehazing

Stereo-based dehazing methods utilize stereo image pairs to estimate depth information, which aids in accurate transmission map computation. These approaches combine stereo matching algorithms with dehazing techniques to achieve improved results, especially in complex and dynamic scenes [4].

2b. Time-of-Flight-Based Dehazing

Time-of-Flight (ToF) cameras capture depth information, which can be beneficial for dehazing. Techniques in this category use ToF data to estimate depth-aware transmission maps, leading to enhanced dehazing performance in scenes with varying distances [5].

2c. Polarization-Based Dehazing

Polarization imaging provides additional information about the scene's polarized light properties. Polarization-based dehazing methods exploit this information to estimate the degree of polarization and improve dehazing results, particularly in challenging outdoor environments [6].

3) Joint Dehazing and Other Tasks

In recent years, researchers have explored joint dehazing and other computer vision tasks, such as object detection, semantic segmentation, and image restoration. By integrating dehazing with other vision tasks, these methods aim to enhance the overall visual understanding of hazy scenes [7].

In the next section, we provide a comparative analysis of these DCP-based image dehazing techniques, evaluating their performance, advantages, and limitations. The analysis aims to offer insights into the effectiveness and suitability of these methods under various hazy conditions and scenarios.

V. METHODOLOGY

The block diagram of the technique suggested is shown in Figure 1. The proposed algorithm combines the technique for prior improvement of the dark channel and the technique for guided filters. Image input from internet sources is hazy or foggy. As a preprocessing step, it is resized to an acceptable level. The dark channel was originally calculated using the three channels red channel, green channel and blue channel. The obtained dark channel is passed through the estimate of atmospheric light. In order to obtain the transfer estimate, the image obtained is processed. This closes the previous step of the dark channel. As described in the introductory part the image obtained is then passed through guided filtering to get a more enhanced picture. In terms of quantitative parameters, the results obtained are visually improved.

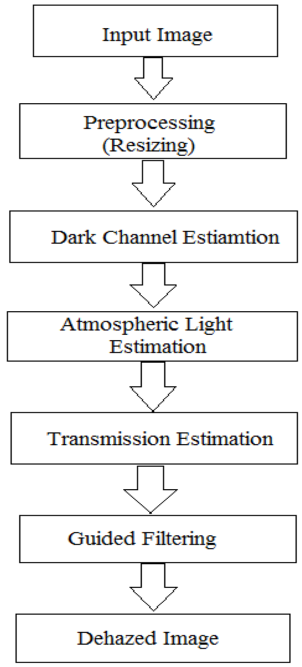

Figure 1: Block Diagram of Methodology

VI. RESULTS & DISCUSSIONS

The algorithm has been tested with a number of different hazy or fogy images. Figure 2 represent the qualitative analysis of the results obtained, showing the hazy image and the dehazed image for various images.

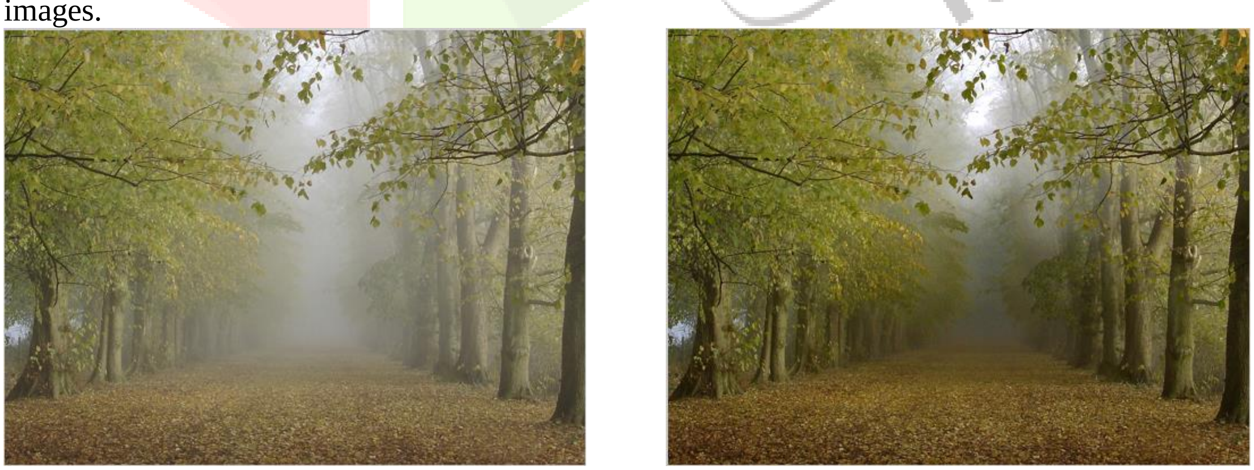

Figure 2: Qualitative Results on Different Hazy Images

To ensure a fair and objective comparison, we employ several standard evaluation metrics commonly used in image dehazing research. Table I shows the results obtained.

Image	MSE	PSNR	Contrast Gain	Correlation
Forest	0.05	61.1441	0.8114	0.8789
Fruits	0.008	68.8966	0.2405	0.9151
Train	0.0471	61.3985	0.9221	0.8306
Satellite	0.0955	58.3290	0.4557	0.8134
Deciduous	0.0065	70.0123	0.0695	0.9124
Highway	0.0102	68.0253	0.3405	0.8932

VI. CONCLUSION

This study considered the problem of image dehazing and enhancement. Images are now transmitted digitally at a high rate and in large quantities. The images are transmitted through noise, which frequently includes hazy or foggy views. DCP is a popular picture dehazing algorithm that was recently implemented for foggy images. In this study, a hybrid approach that combines the previous method with the guided filtering method is proposed to remove the haze content in an image. The software MATLAB is used to create implementation for the proposed algorithm, which is evaluated using quantitative and qualitative performance measures. The proposed algorithm was evaluated using a number of parameters such as the MSE, Contrast Gain, PSNR, and SSIM.

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