Refined DCP: High-Quality Image Defogging

Riya Shaw, Sristy Bhattacharyya, Pronomi Biswas, SoumiMitra, Dr. Sangita Roy, Arpita Santra, Abhijit Ghosh
ECE Department, Narula Institute of Technology

ABSTRACT:

A robust image defogging algorithm is designed to address issues such as low visibility, poor contrast and loss of detail in rainy and foggy conditions. This method enhances images by redefining color channels, applying color compensation, and mitigating darkening using dark channel algorithm which has been improved with enhanced Atmospheric Light Estimation(about 90 percentile brightest pixels) and introduced Lab color space to adjust the color balance.

Major improvements include:
Natural Images: Increased information entropy and NIQE.
Synthetic datasets (I-HAZE & O-HAZE): Improved information entropy, NIQE, PSNR, and SSIM.The algorithm outperforms current methods in clarity, quality, and robustness, making it very promising for real-world applications. This paper addresses the challenges of recovering clean, high-quality images degraded by adverse weather conditions such as fog, mist, and rain. Key contributions include improvements to existing haze removal methods and the introduction of an improved Atmospheric Scattering Model (ASM).

Keywords-Dehazing, Defogging, DCP, ASM, scattering coefficient.

I. Introduction:

Image clarity is reduced due to haze particles, which leads to color distortion and loss of detail. Traditional detection methods struggle with atmospheric scattering models[1], color aberrations, and detail restoration. Accurate turbidity modeling and depth estimation are critical for realistic image reconstruction. A priori methods: Use models like Dark Channel Prior (DCP)[2] to remove haze, but they can cause color distortion and darkening, especially in sky areas[3]. Deep learning-based methods[4]: Use neural networks (e.g., DehazeNet, AOD-Net) for throughput estimation, but often rely heavily on specific datasets and face challenges in generalizing to real-world scenarios[5]. It introduces a light absorption coefficient to traditional ASM, solves color distortion and darkness after defogging. Color Correction Preprocessing: Applies color correction before de-hazing to ensure authentic color representation and optimal brightness.

Adaptive Color Correction: Combines minimal color loss and maximum attenuation mapping to reduce color distortion in sky areas. For efficiency, permeability maps are derived using simplified quadratic equations.

The proposed algorithm outperforms the IDE algorithm[6] in preserving the fidelity of colors and details. It achieves excellent results in metrics such as information entropy, SSIM[11], and NIQE[12], demonstrating improved visual quality and robustness.

The proposed algorithm effectively addresses the limitations of existing deblurring methods, offering higher color fidelity, better detail preservation, and better performance across various image quality metrics, making it a promising solution for real-world applications.

I. IMPROVED DARK CHANNEL DEFOGGING ALGORITHM

A. IMPROVED ATMOSPHERIC SCATTERING MODEL

The section discusses an Improved Atmospheric Scattering Model (ASM) for image defogging, addressing the limitations of traditional ASM in adverse weather conditions like fog and haze.

1. Traditional ASM:

· Describes hazy images as a combination of attenuated light and atmospheric light[7]:

$$I(x) = J(x)t(x) + A[1 - t(x)] \quad (1)$$

· Transmittance is calculated as $t(x) = e^{-\beta d(x)}$, $\beta d(x)$where is scene depth[8] and β is the scattering coefficient. Fails to account for light absorption by textured regions, leading to darker recovered images.

2. Improved ASM:

· Introduces a light absorption coefficient (ϵ\epsilonϵ) to model light absorption during propagation:

· $$I(x) = A.(1-\in(x)).\sigma(x).t(x) + A[1 - t(x)] \quad (2)$$

· Defines $\in(x)$ as depth-dependent:

$$\in(x) = 1 - \frac{d(x)}{max(d)} \quad (3)$$

3. Final Model:

· Incorporates the logarithmic relationship between transmittance and depth into the ASM:

$$I(x) = A.\frac{In(t(x))}{In(t_{min})}.t(x) + A[1 - t(x)] \quad (4)$$

· Simplifies the logarithmic function using MATLAB fitting:

$$In(t) \approx \frac{-0.397}{0.7774+t} \quad (5)$$

. Uses a quadratic equation and the golden section search algorithm to estimate transmittance efficiently.

4. Dark Channel Prior (DCP):

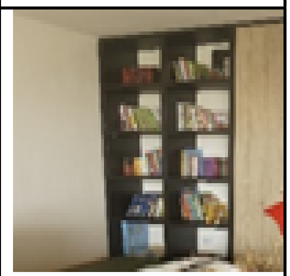
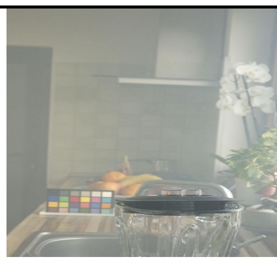
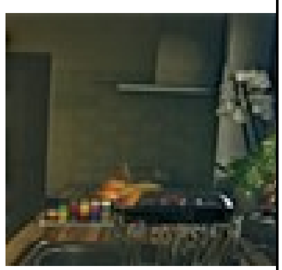
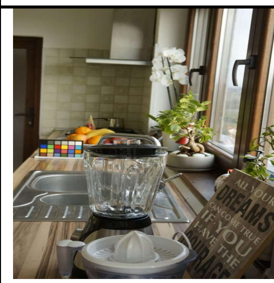
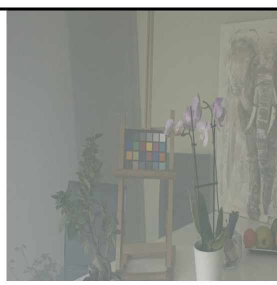
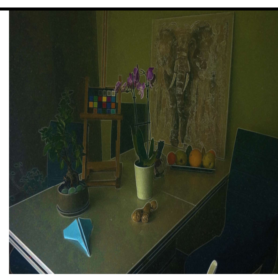
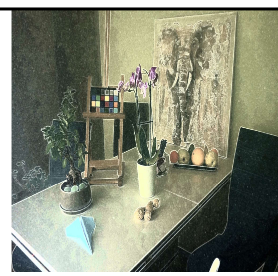
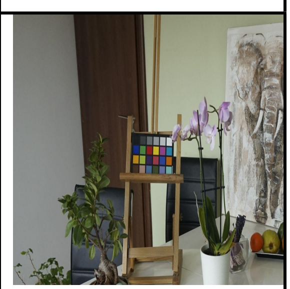
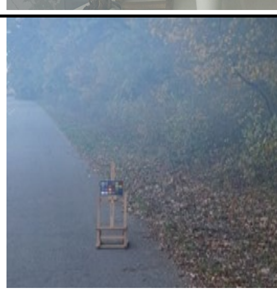
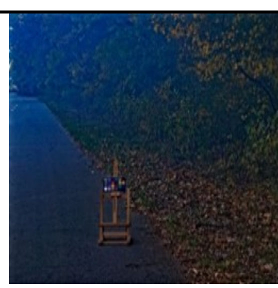
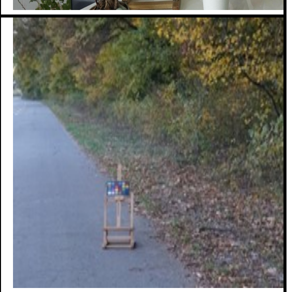
Leverages the dark channel before estimating atmospheric light: Finds the smallest pixel value in each colour channel within a local window. Identifies the brightest pixels as atmospheric light values. Colour Aberration: Natural images may exhibit colour distortion post-recovery.

Solution: In subsequent sections, a colour correction algorithm is proposed to address these issues.

II. COLOR CORRECTION:

Dark Channel Prior (DCP) algorithm for removing turbidity in images. Using a filter window, calculates the dark channel by identifying the minimum intensity across the RGB channels [9]. Atmospheric light, which represents the brightest regions, is estimated by dark channel analysis. A transmission map indicating the intensity of turbidity is calculated based on the dark channel and atmospheric light. Finally, the blurred image is restored by inverting the blur effect, ensuring valid pixel values. A post-processing step adjusts the colour balance using histogram equalization to improve colour quality. Users can upload blurry images and visualize dark channels, transmission maps and blurry outputs.

TABLE 1: Comparative data insets

No	Hazy Image	DCP	Modified DCP	Ground Truth
1				
2				
3				
4				
5				

6				
7				
8				

TABLE II: Quantitative evaluation

Image No.	NIQE	PSNR (in dB)	SSIM
1.	3.1939	27.82773961759370	0.346175934738457
2.	2.3393	28.12527925705923	0.334725795658906
3.	3.9332	27.77030314908017	0.271073717691336
4.	2.2657	27.78606898806152	0.372578288802253
5.	6.6745	28.01237784024425	0.249004124227160
6.	3.5342	27.79697121952546	0.360276255064607
7.	1.9144	28.02362121295338	0.496036572056742
8.	4.9988	27.76814710302377	0.269539041245381

III. EXPERIMENTAL RESULTS AND ANALYSIS:

The paper evaluates a proposed algorithm for image defogging using real and public datasets (I-HAZE [10] and O-HAZE), comparing it with standard DCP algorithm. Subjective evaluation shows the proposed method achieves better fog removal, enhances details, and improves color accuracy, outperforming others in maintaining visual clarity and reducing distortions.

IV. CONCLUSION:

The paper presents an unsupervised single-image color removal algorithm that combines a color correction model and a color removal model. The algorithm demonstrates the robustness and excellent performance on real and synthetic datasets, improving color fidelity and recovering scene details without training data. Experimental results show that it reduces color aberration, improves visual quality, and has wide application potential.

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