International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Enhanced Image Dehazing Using Bright and Dark Channel Prior

Sana Subramanyam[1], Kasam Neeraja[2], Marri Ganesh[3], Vadlakonda Srinidhi[4], Gajula Rohith[5]

[1]*Electronics and communication, Jyothishmathi institute of technology and science*
[2]*Electronics and communication, Jyothishmathi institute of technology and science*
[3]*Electronics and communication, Jyothishmathi institute of technology and science*
[4]*Electronics and communication, Jyothishmathi institute of technology and science*
[5]*Electronics and communication, Jyothishmathi institute of technology and science*

---***---

ABSTRACT - Visibility degradation caused by haze presents a major challenge for computer vision systems in outdoor environments. This project introduces an enhanced image dehazing method based on Bright and Dark Channel Prior (BDCP), an improvement over traditional dark channel technique. By incorporating both bright and dark channel information, the method more effectively estimates the transmission map and atmospheric light, resulting in clearer and more natural dehazed images. The proposed algorithm refines visual quality through a fusion-based enhancement and edge-preserving filtering. Extensive experiments demonstrate that this approach significantly outperforms conventional methods in terms of contrast restoration and color fidelity, particularly under dense haze conditions.

Key Words: Image Dehazing, Dark Channel Prior, Bright Channel Prior, Transmission Estimation, Atmospheric Light, Visibility Restoration, Haze Removal, Image Enhancement.

1. INTRODUCTION

Hazy conditions in outdoor environments significantly degrade image quality by reducing contrast and distorting colours. This presents a challenge for computer vision applications such as autonomous driving, surveillance, and remote sensing. Image dehazing techniques aim to restore clear visuals by compensating for atmospheric scattering effects.

This project presents an enhanced image dehazing approach that combines Bright and Dark Channel Priors (BDCP). While the Dark Channel Prior is effective for estimating dense haze regions, it can result in artifacts or over-saturation in bright areas. By incorporating the Bright Channel Prior, the proposed method achieves better balance and accuracy in estimating the transmission map and atmospheric light.

The enhanced technique improves visibility restoration, preserves natural colours, and enhances structural details even under thick haze. This method shows superior performance over conventional models, making it suitable for real-world applications that demand high visual clarity.

2. LITERATURE SURVEY

Image dehazing techniques aim to restore visibility in scenes affected by atmospheric particles. The Dark Channel Prior (DCP) has been widely used for estimating haze density, but it often introduces artifacts in bright regions. To overcome these issues, the Bright Channel Prior (BCP) was proposed as a complementary method. Recent studies show that combining both priors leads to more accurate transmission estimation and better visual quality.

Several enhancements, such as guided filtering and adaptive refinement, have been applied to improve edge preservation and reduce noise. These advancements provide a strong foundation for the proposed method, which seeks to deliver more natural and artifact-free dehazed images. proposed method enhances image dehazing by combining Dark Channel Prior (DCP) and Bright Channel Prior (BCP) to handle both dark and bright regions effectively.

3. EXISTING SYSTEM

Traditional image dehazing methods rely heavily on single priors or global contrast enhancement techniques. One of the most well-known approaches is the Dark Channel Prior (DCP), which assumes that at least one colour channel in non-sky regions has low intensity. This technique enables estimation of the transmission map and atmospheric light, leading to reasonable haze removal. However, DCP often struggles in bright or white regions, where its assumptions do not hold, resulting in artifacts or colour distortions.

To address these limitations, researchers have explored improvements such as guided filtering, soft matting, and depth estimation techniques. Some learning-based methods have also emerged, using neural networks trained on synthetic datasets. While these approaches show promise, they often require large amounts of data, are computationally intensive, or fail in highly illuminated scenes. As a result, there remains a need for lightweight and effective methods capable of handling both bright and dark regions in a single framework.

4. PROPOSED SYSTEM

The proposed system improves single image dehazing by combining enhanced bright and dark channel priors for better haze removal. It starts by extracting the bright channel to accurately estimate atmospheric light, reducing errors caused by bright objects or reflections. The dark channel prior is used to compute the initial transmission map, representing haze density. This map is then refined using an adaptive edge-preserving filter to eliminate artifacts like halos while preserving scene details.

Finally, the system reconstructs the haze-free image by inverting the atmospheric scattering model. Post-processing steps improve colour and contrast for visually natural results. This method enhances haze removal effectiveness, reduces common artifacts, and produces clearer, more natural images from hazy inputs.

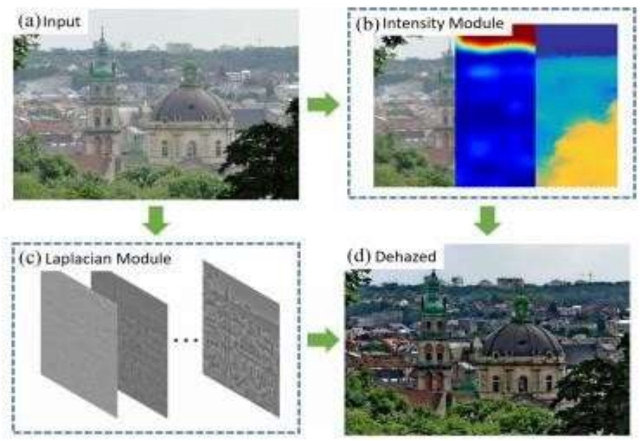

Fig -1: Flow Diagram of the Proposed Method

5. SYSTEM ARCHITECTURE

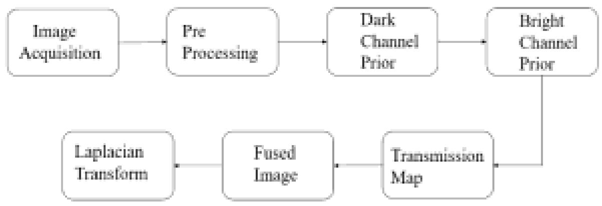

Fig -2: Block Diagram

The proposed system for image dehazing integrates multiple techniques—Dark Channel Prior (DCP), Bright Channel Prior (BCP), and Laplacian Transform—to improve visibility restoration in hazy images. The overall design emphasizes a fusion-based approach to leverage the strengths of each method and produce more accurate and visually appealing results.

1. Image Acquisition

The system begins with the image acquisition phase. In this step, hazy images are obtained either from real-world outdoor scenes or benchmark image datasets specifically designed for haze research. The quality and diversity of input images significantly affect the performance of the dehazing system. Natural haze typically varies in density and distribution, so capturing a wide range of hazy images ensures better generalizability of the model.

2. Pre-Processing

Before applying dehazing algorithms, the images undergo pre-processing. This step includes:

Resizing: Standardizing image dimensions for computational efficiency.

Noise Reduction: Removing sensor noise that may interfere with haze estimation.

Color Space Conversion: Converting from RGB to other color spaces (e.g., HSV or YCbCr) if needed for more effective analysis.

Histogram Equalization (optional): Enhancing contrast to better differentiate between hazy and non-hazy regions.

Pre-processing is crucial for improving the consistency and quality of the results obtained from subsequent steps.

3. Dark Channel Prior (DCP)

DCP is a widely used method for estimating haze in an image. It is based on the empirical observation that in most non-sky patches of outdoor haze-free images, at least one-color channel often has very low intensity. This "dark channel" becomes less prominent in the presence of haze. By computing the dark channel and estimating atmospheric light, a rough transmission map is obtained, which reflects the density of haze in various parts of the image.

To overcome these drawbacks, the Bright Channel Prior is introduced as a complementary technique.

4. Bright Channel Prior (BCP)

Bright Prior is designed to address the deficiencies of DCP, especially in sky and brightly lit regions. While DCP focuses on minimum intensities, BCP analyzes maximum intensity values within image patches. The assumption here is that bright pixels in the haze-free image should remain visible and distinguishable even in hazy conditions.

BCP helps improve the visibility of overexposed or high-luminance areas, leading to a more balanced and natural dehazing result.

5. Transmission Map Estimation

From the fused image, a refined transmission map is computed. The transmission map represents the portion of light that reaches the camera without being scattered or absorbed. It is a critical component for estimating the haze-free image using the atmospheric scattering model.

6. Fused Image

The outputs from the DCP, BCP, and Laplacian Transform modules are combined in a fusion step. This fusion integrates:

The depth estimation from DCP.
The brightness compensation from BCP.
The detail enhancement from the Laplacian Transform.

7. Laplacian Transform

The Laplacian Transform is applied to enhance image features by emphasizing edges and texture. As a second-order derivative operation, it helps identify rapid changes in intensity, which often correspond to object boundaries. This step is particularly useful for:

Preserving structural details.
Refining the haze boundary,
Reducing blurring during the dehazing process.

6. RESULTS

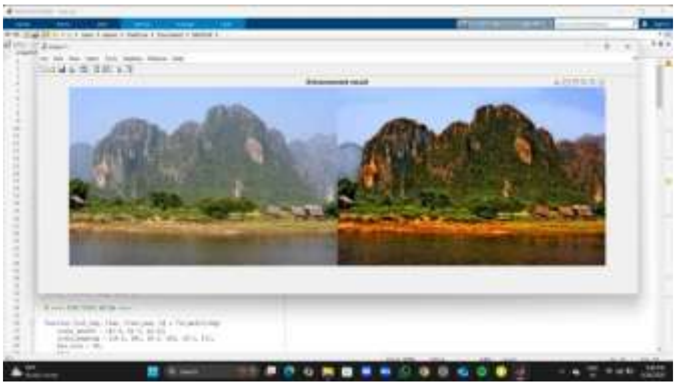

Fig -3: Output Image

The output image clearly demonstrates the effectiveness of the proposed dehazing method. As seen in Fig. 2, the left side shows the original hazy image, while the right side displays the enhanced version. The visibility of distant objects, such as mountains and huts, is significantly improved, and the overall scene appears more vivid and clear.

The combined use of Bright and Dark Channel Priors has resulted in a more accurate transmission map, enabling better removal of haze and restoration of scene details. The colours in the enhanced image are more natural, and contrast is notably improved, especially in regions that were previously faded or poorly lit. This visual improvement supports the methods potential for real-world outdoor imaging applications.

7. CONCLUSION

This introduced a versatile image enhancement method for single image dehazing by combining the advantages of a model and fusion-based methods. Input images were decomposed into intensity and Laplacian modules for pixel and gradient level enhancement. As detail layers secure gradient information, the output image produces results with guaranteed detail even under smoothed transmission. The proposed method was verified under various scenarios, as well as through single image comparison and robot vision application.

8. FUTURE SCOPE

The future scope includes several avenues for enhancement. One potential direction is refining the current model to adapt to diverse climatic conditions prevalent across India, such as monsoons, fog, and dust storms, which significantly affect image quality. Incorporating real-time adaptability using machine learning techniques could further improve dehazing efficiency. Additionally, integrating advanced deep learning algorithms to optimize ambient light estimation and transmission map computation can lead to faster, more accurate results. Finally, expanding the scope to process video sequences and real-time applications like autonomous driving, traffic monitoring, and aerial surveillance in Indian environments would elevate its practical utility.

REFERENCES:

[1] G. L. Foresti, “Visual inspection of sea bottom structures by an autonomous underwater vehicle,” IEEE Trans. Syst., Man, Cybern. B,Cybern., vol. 31, no. 5, pp. 691–705, Oct. 2001.

[2] Y. Kahanov and J. G. Royal, “Analysis of hull remains of the Dor D Vessel, Tantura Lagoon, Israel,” Int. J. Nautical Archeol., vol. 30, pp.257–265, Oct. 2001.

[3] A. Ortiz, M. Simó, and G. Oliver, “A vision system for an underwater cable tracker,” Mach. Vis. Appl., vol. 13, pp. 129–140, Jul. 2002.

[4] A. Olmos and E. Trucco, “Detecting man-made objects in unconstrained subsea videos,” in Proc. BMVC, Sep. 2002, pp. 1–10.

[5] S. G. Narasimhan and S. K. Nayar, “Contrast restoration of weather degraded images,” IEEE Trans. Pattern Anal. Mach. Learn., vol. 25, no. 6, pp. 713–724, Jun. 2003.

[6] C. H. Mazel, “In situ measurement of reflectance and fluorescence spectra to support hyperspectral remote sensing and marine biology research,” in Proc. IEEE OCEANS, Sep. 2006, pp. 1–4.

[7] M. D. Kocak, F. R. Dalgleish, M. F. Caimi, and Y. Y. Schechner, “A focus on recent developments and trends in underwater imaging,” Marine Technol. Soc. J., vol. 42, no. 1, pp. 52–67, 2008.

[8] B. A. Levedahl and L. Silverberg, “Control of underwater vehicles in full unsteady flow,” IEEE J. Ocean. Eng., vol. 34, no. 4, pp. 656–668, Oct. 2009.