Plug-and-Play Image Dehazing with DRUNet Priors

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Motivation

- Haze caused by atmospheric scattering reduces contrast, distorts colors, and obscures scene details. Recovering a clear scene from a single hazy image is challenging due to unknown transmission maps and atmospheric light.

$$I(x) = J(x)t(x) + A(1 - t(x))$$

- Traditional image priors can fail in bright or sky regions, producing color shifts and halo artifacts. Deep learning methods often rely on synthetic training data and may generalize poorly to real-world haze.
- Can we achieve high-quality, training-free dehazing by leveraging modern denoisers like DRUNet as image priors?

Hazy image (left), ground truth (middle), and transmission map (right).

Related Work

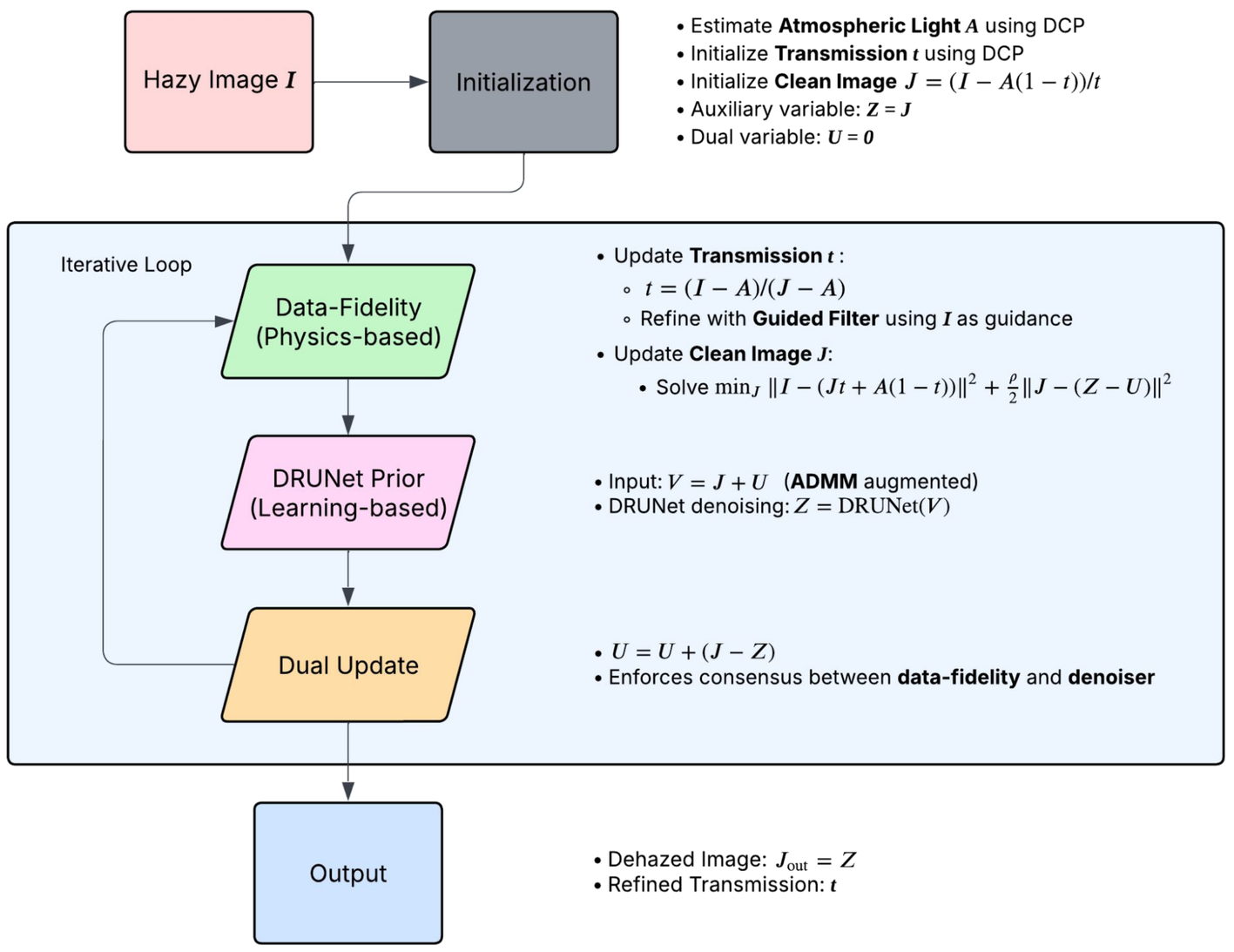
- Physics-based priors like **Dark Channel Prior** (DCP) estimate transmission and atmospheric light, but struggle in bright or low-contrast regions [1].
- End-to-end deep learning methods (**AOD-Net**, **DehazeNet)** show excellent performance on synthetic haze datasets but may generalize poorly to real scenes [2,3].
- Joint optimization approaches combine physical models with learned priors to improve stability [4].
- **Plug-and-Play** (PnP) methods avoid task-specific training by using pre-trained denoisers iteratively within the haze model, offering a more flexible, training-free solution [5].
- The effectiveness of PnP heavily depends on the choice of denoiser, motivating the exploration of modern architectures like **DRUNet** [5].

References

[1] He et al., Single Image Haze Removal Using Dark Channel Prior, IEEE TPAMI, 2009.
[2] Li et al., AOD-Net: All-in-One Dehazing Network, ICCV, 2017.
[3] Cai et al., DehazeNet: An End-to-End System for Single Image Haze Removal, TIP, 2016.
[4] Zhang et al., Joint Transmission Map Estimation and Dehazing with Deep Priors, CVPR, 2018.
[5] Graikos et al., Diffusion Models as Plug-and-Play Priors, CVPR, 2022.

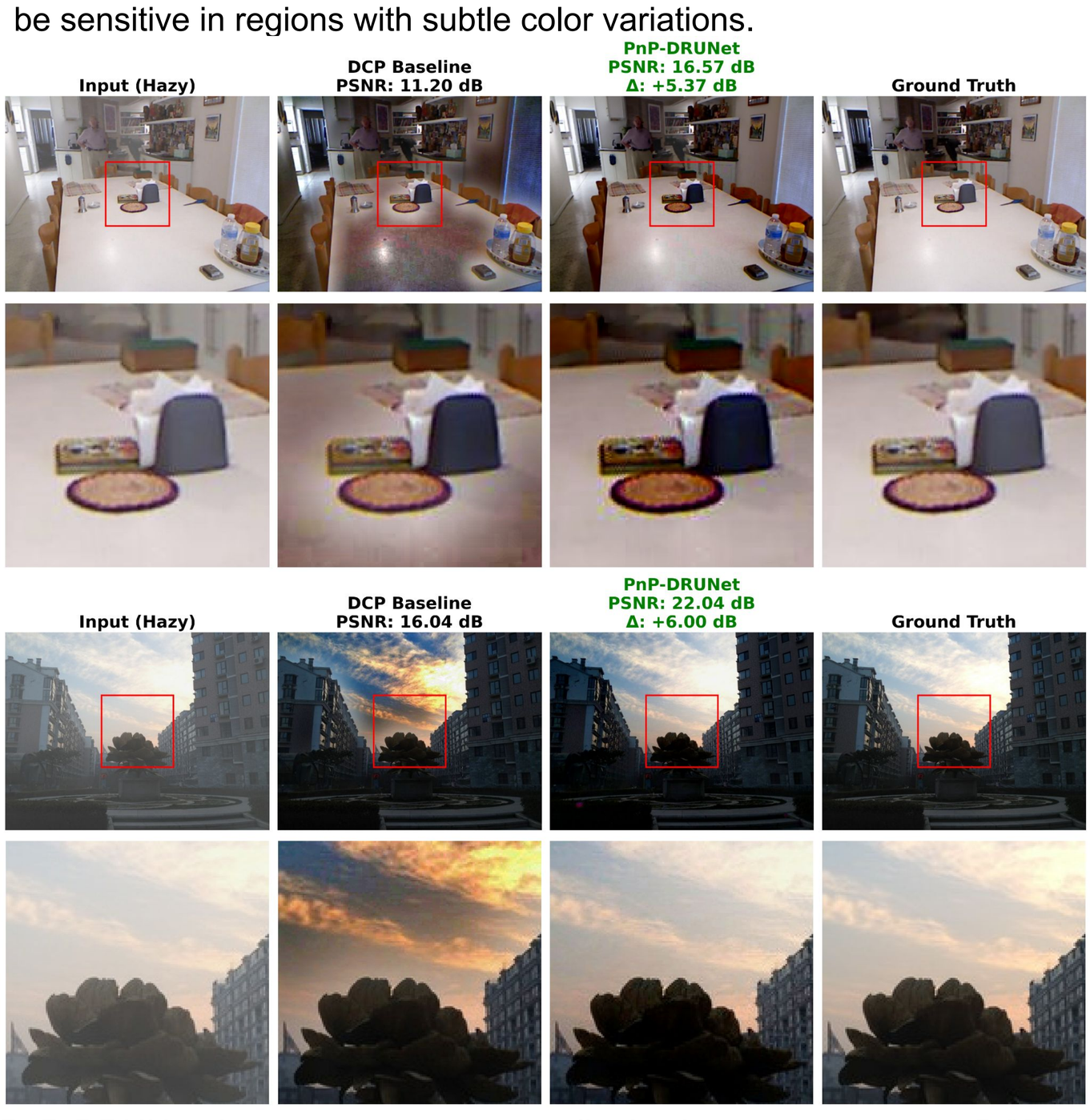
New Technique

We introduce **PnP-DRUNet**, an **ADMM**-based method that alternates between enforcing the haze model and denoising with a pretrained DRUNet prior—yielding a training-free dehazing algorithm.



Experimental Results

The visual comparisons show that PnP-DRUNet yields clearer structures, fewer artifacts, and higher contrast than DCP. The method better handles challenging regions such as sky areas, low-texture surfaces, and fine high-frequency details, though performance may still be sensitive in regions with subtle color variations.



PnP-DRUNet demonstrates strong qualitative improvements over DCP by combining physics-based data fidelity with a modern pretrained denoiser.