Joint qualitative and quantitative evaluation of fast image dehazing based on dark channel prior

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Abstract

Haze is an undesirable effect in images caused when atmospheric particles are lit directly or indirectly by the sun. This effect can be counteracted by image processing, to bring back the details of a hazy image. In this work, we propose to tune several parameters of the Dark Channel Prior method (DCP) algorithm combined with the fast guided filter. We evaluate the optimization in terms of execution time, and quantify the output image quality using different image quality metrics.

Dark Channel Prior

The dark channel concept: the minimum of intensities among all color components and within a small area of pixels is always close to zero in a haze-free image.

1. **Dark Channel Prior**

$$I^{dark}(\mathbf{x}) = \min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_{c\in(r,g,b)}\left(I^c(\mathbf{y})\right)\right), \quad (1)$$

where I^{dark} is the dark channel, I^c is the intensity in spectral channel c, and $\Omega(\mathbf{x})$ is a local patch centered at position x.

2. **Airlight Estimation**

3. **Transmission Estimation**

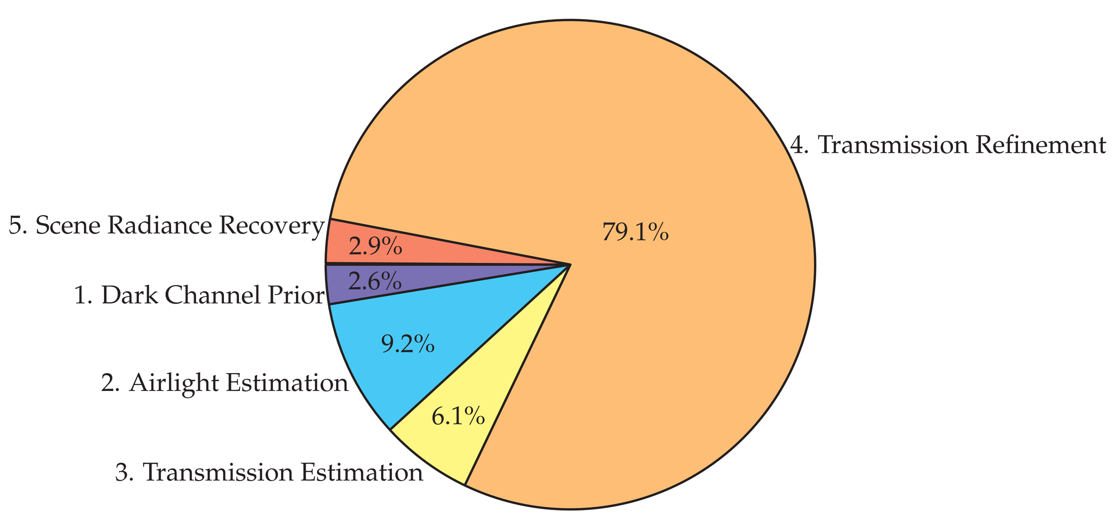
$$\hat{t}(\mathbf{x}) = 1 - \min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_{c\in(r,g,b)}\left(\frac{I^c(\mathbf{y})}{A^c}\right)\right), \quad (2)$$

4. **Transmission Refinement**

To restore the edges in the transmission map, the refinement of the transmission map is done by using a soft matting Laplacian [5] or guided filtering [4].

5. **Scene Radiance Recovery**

$$\mathbf{J}(\mathbf{x}) = \frac{\mathbf{I}(\mathbf{x}) - \mathbf{A}}{\max(t(\mathbf{x}), t_0)} + \mathbf{A}, \quad (3)$$



Imaging Model

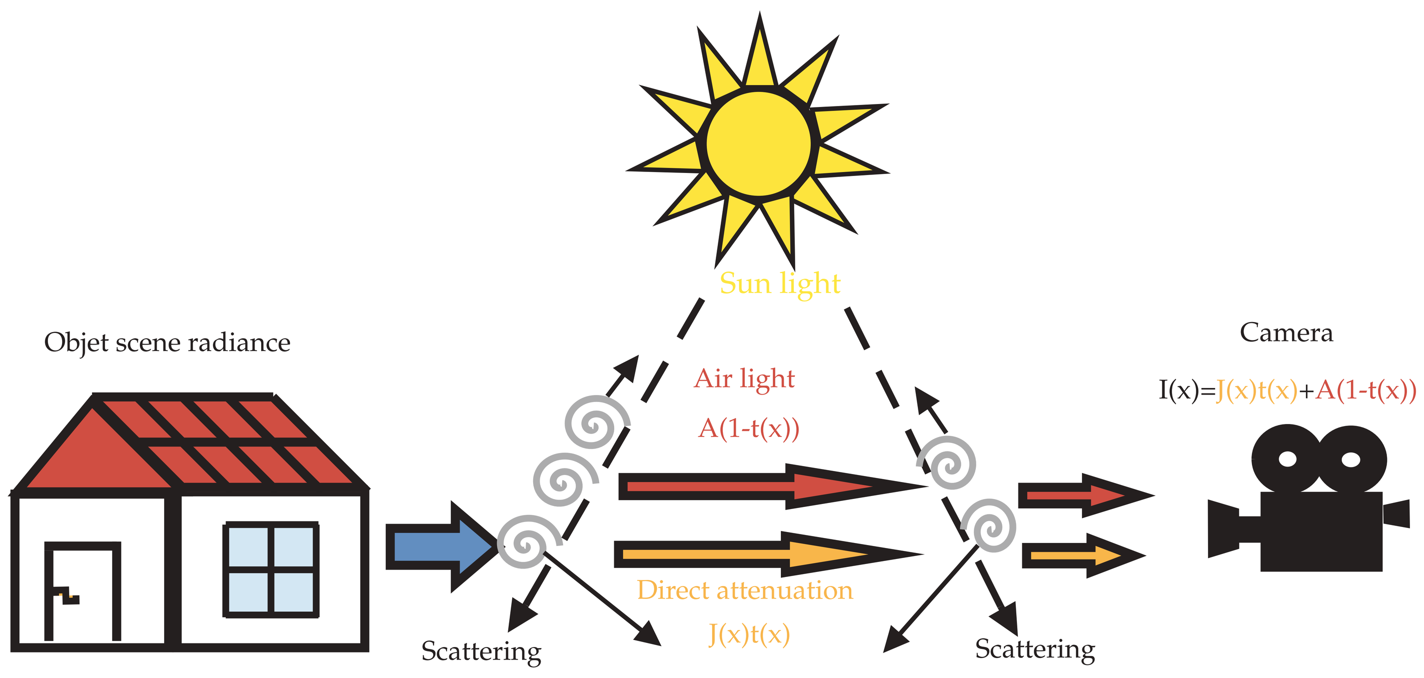


Figure 1: Imaging of a scene through haze. The illumination is scattered by the atmospheric particles and acts as an additive intensity component to the object radiance.

Quantitative evaluation

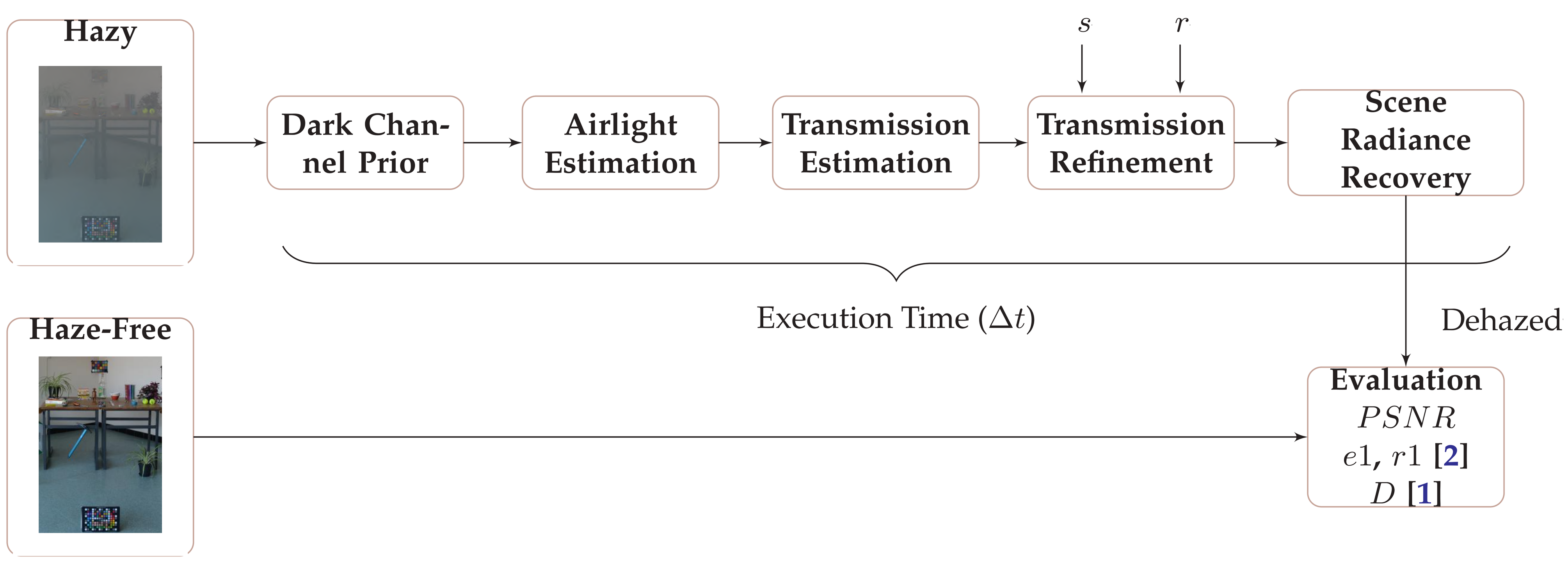


Figure 2: Experimental pipeline used in this work. The sampling factor s and the radius r are the parameters which are made variable.

DCP Fast (DCPF)

An optimized version of DCP proposed by [4]: the soft matting is substituted by a guided image filtering based on a local computation of linear coefficients.

An optimization of the guided image filtering by [3]. They reduce the resolution during the refinement step 4, using a subsampling before to compute coefficients, followed by an upsampling.

Optimization Strategy This seems judicious to make the sampling factor s and the radius r of the filter window variables. We propose to jointly evaluate these parameters relatively to the image quality and the execution time.

Results (metrics)

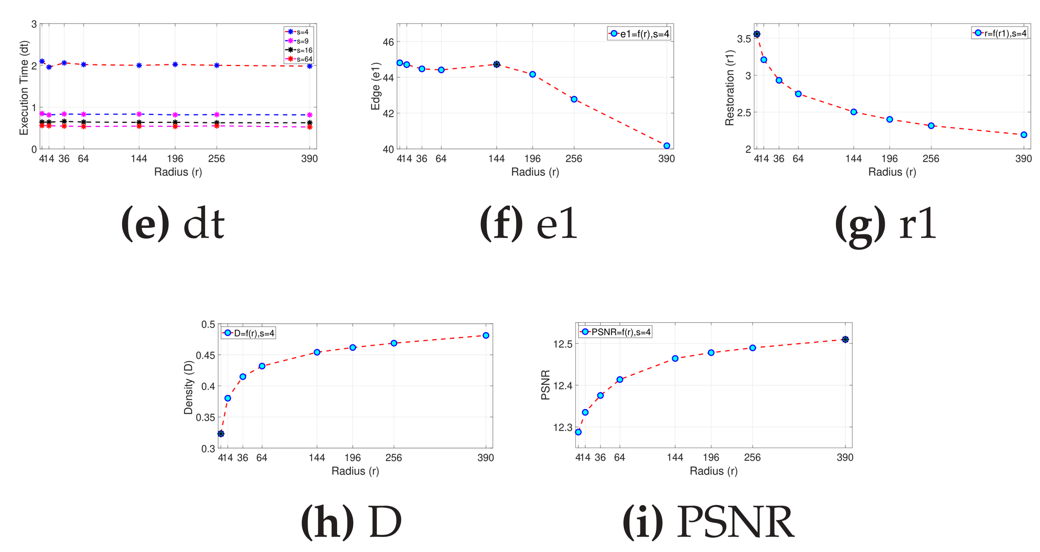


Figure 1: Metric results when the sampling factor s is kept constant.

Visualization

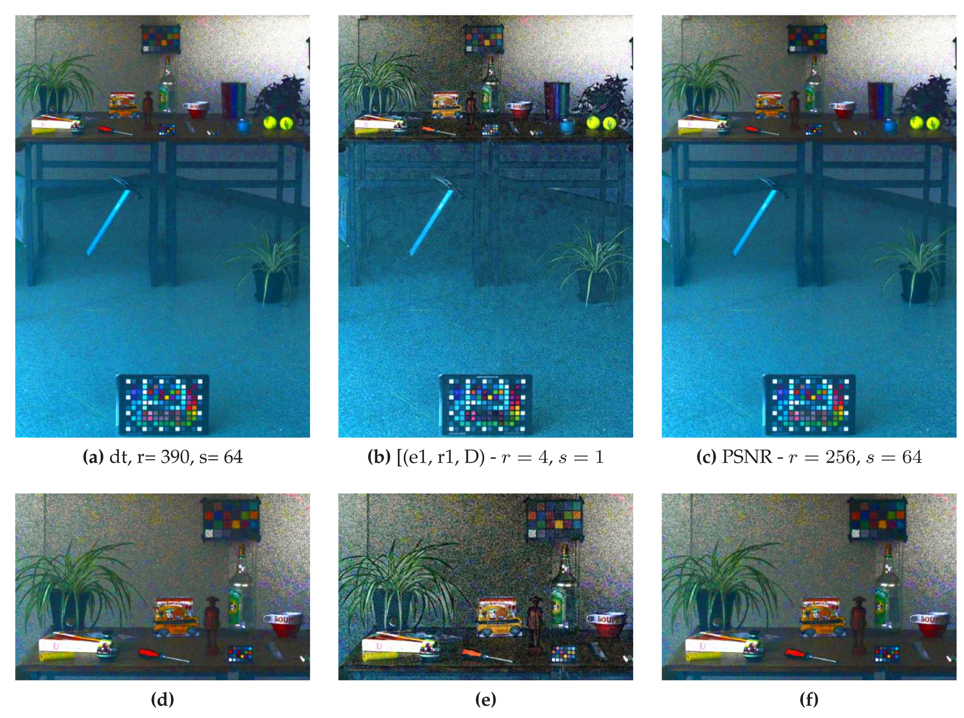


Figure 2: Visualization of the best dehazed images for each considered metric in the set of tested combinations, and (d)-(f) zoomed versions.

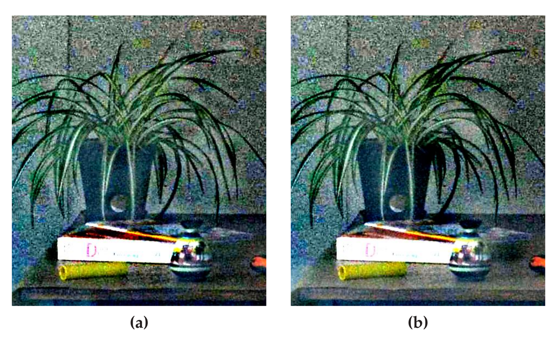


Figure 3: Visualization of the artifacts and halos when radius . The artifacts grow as the difference between r and s increases.

Reference

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