Dehazing single image using Dark Channel Prior

DIP Project

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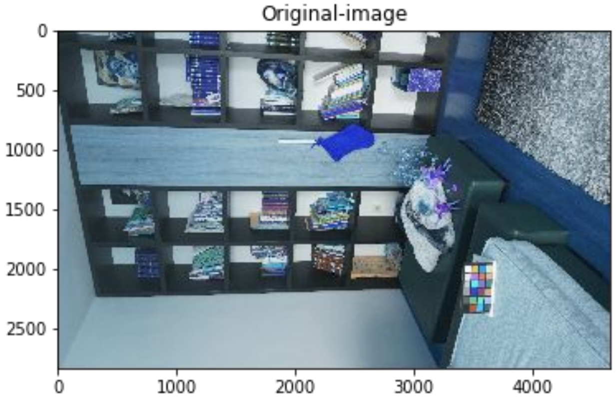
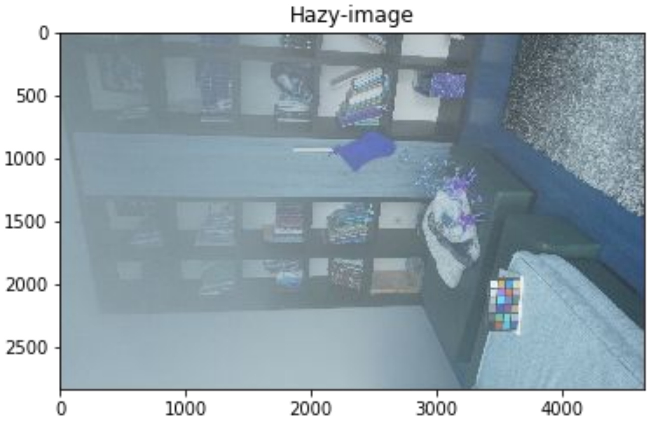
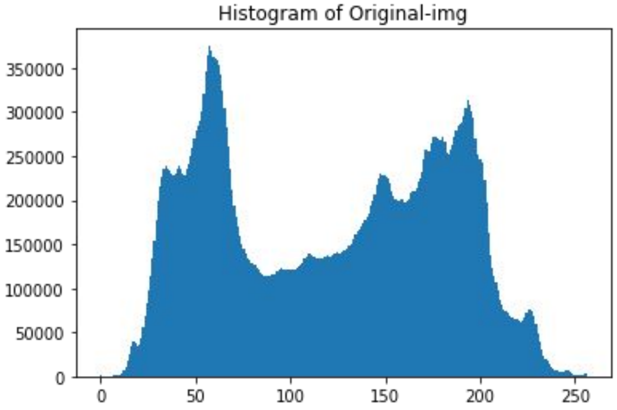
Introduction

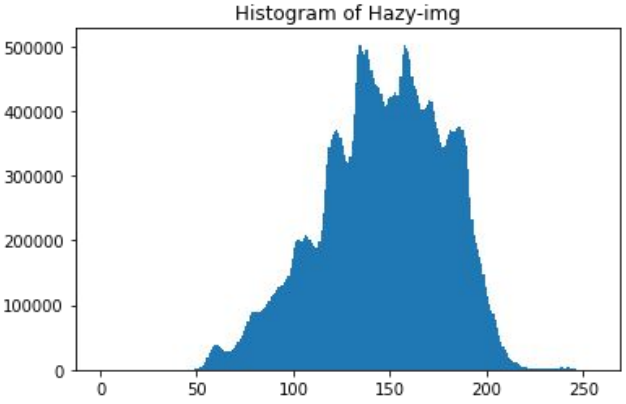
- Haze, fog, and smoke are phenomena due to atmospheric absorption and scattering.
- Images of outdoor scenes are usually degraded by them.
- The haze-free image is more visually pleasing.
- Removing haze can significantly increase the visibility of the scene and correct the color shift caused by the airlight
- Haze removal (or dehazing) is highly desired in consumer/computational photography and computer vision applications.

Dehazing with histogram equalization

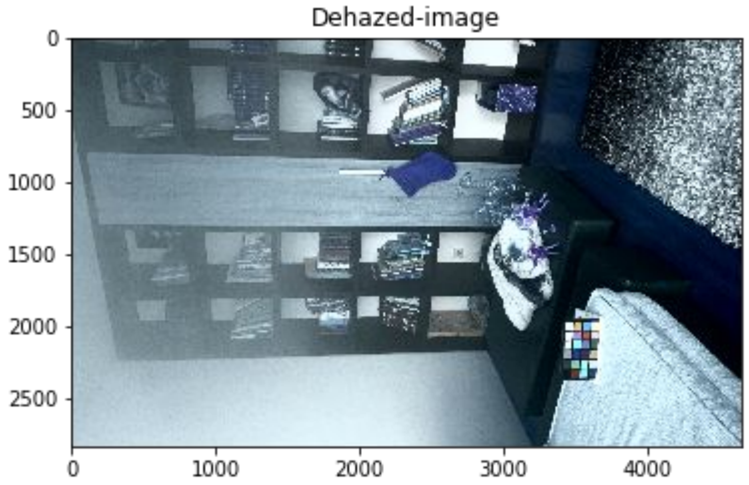


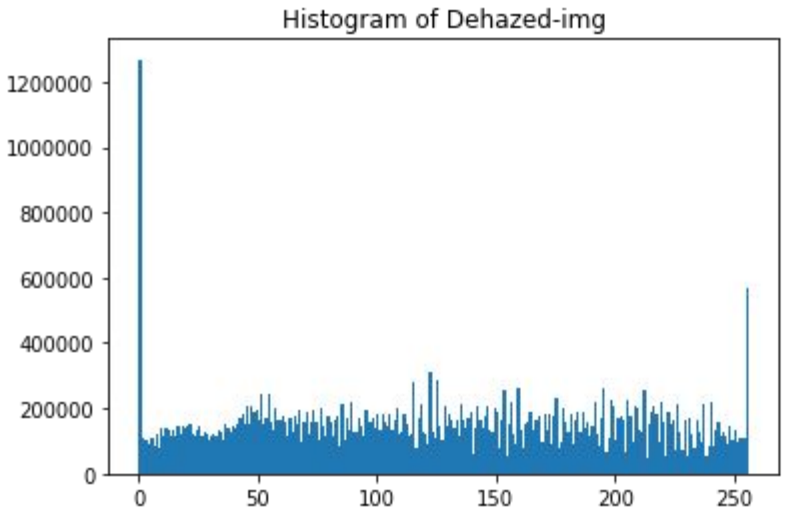






Dehazing with histogram equalization





Results after Histogram Equalization

Haze Imaging Model

$$\mathbf{I}(\mathbf{x}) = \mathbf{J}(\mathbf{x})t(\mathbf{x}) + \mathbf{A}(1 - t(\mathbf{x}))$$

- **I** is the observed intensity
- **J** is the scene radiance
- **A** is the global atmospheric light
- **t** is the medium transmission (describing the portion of the light that is not scattered and reaches the camera)
- **A(1-t(x))** is Airlight
- **J(x)t(x)** is direct attenuation

Dark channel prior

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

- J^{dark} is a color channel of J
- Ohm(x) is a local patch (15x15) centered at x.

Dark channel prior

$$J^{\text{dark}} \rightarrow 0.$$

The basic observation (called **Dark-channel prior**) is that on haze-free outdoor images, most of the non-sky patches, at least one color channel has very low intensity at some pixels. The low intensities in the dark channel are mainly due to:

- Dark objects, shadows of trees and rocks.
- Colorful objects Ex- green, red, yellow, blue

Since the natural outdoor images are usually colorful and full of shadows, it is reasonable to generalize the observation.

Dehazing using deep channel prior

- We normalize each color channel independently

$$\frac{I^c(\mathbf{x})}{A^c} = t(\mathbf{x})\frac{J^c(\mathbf{x})}{A^c} + 1 - t(\mathbf{x}).$$

- Calculate the dark channel on both sides

$$\min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_c \frac{I^c(\mathbf{y})}{A^c}\right) = \tilde{t}(\mathbf{x}) \min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_c \frac{J^c(\mathbf{y})}{A^c}\right) + 1 - \tilde{t}(\mathbf{x}).$$

Dehazing using deep channel prior

- As the scene radiance J is a haze-free image, the dark channel of J is close to zero due to the dark channel prior

$$J^{\text{dark}}(\mathbf{x}) = \min_{\mathbf{y} \in \Omega(\mathbf{x})} \left(\min_{c} J^{c}(\mathbf{y}) \right) = 0.$$

- Thus eliminate the multiplicative term and estimate the transmission t~

$$\tilde{t}(\mathbf{x}) = 1 - \min_{\mathbf{y} \in \Omega(\mathbf{x})} \left(\min_{c} \frac{I^{c}(\mathbf{y})}{A^{c}} \right)$$

Dehazing using deep channel prior

- The color of the sky in a hazy image I is usually very similar to the atmospheric light A. So, in the sky region

$$\min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_{c}\frac{I^c(\mathbf{y})}{A^c}\right) \to 1$$

- keep a very small amount of haze for the distant objects by introducing a constant parameter (0 < Omega<= 1)

$$t(\mathbf{x}) = e^{-\beta d(\mathbf{x})}$$

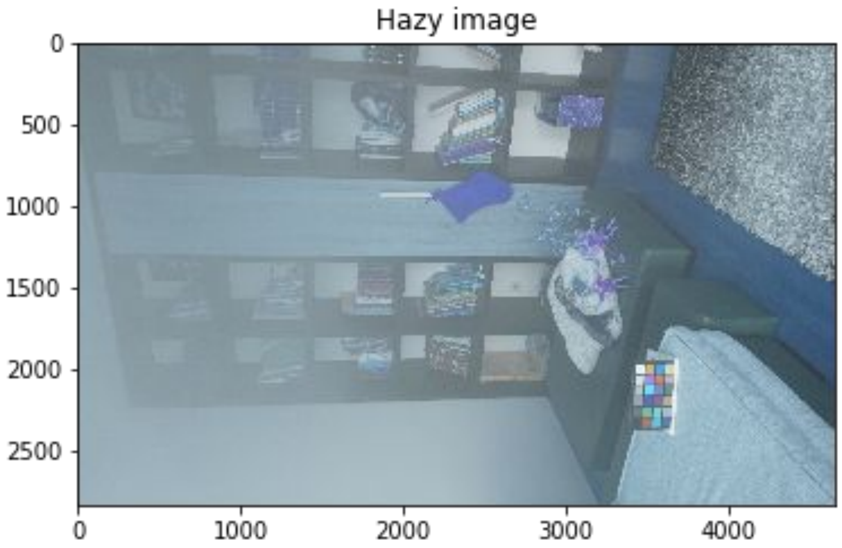
$$\tilde{t}(\mathbf{x}) = 1 - \omega \min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_{c}\frac{I^c(\mathbf{y})}{A^c}\right)$$

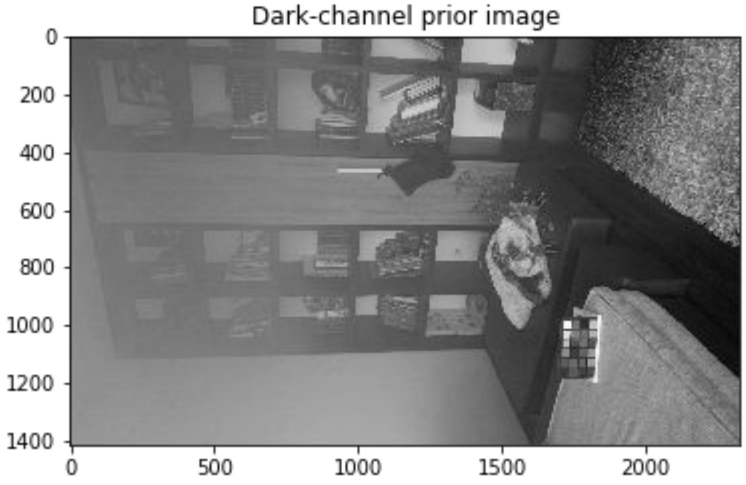
Dehazing using deep channel prior

- Use the dark channel image to detect the most haze-opaque region and improve the atmospheric light estimation.
- We first pick the top 0.1 percent brightest pixels in the dark channel. These pixels are usually most haze-opaque.
- Among these pixels, the pixels with highest intensity in the input image I are selected as the atmospheric light.
- Recovered Image:

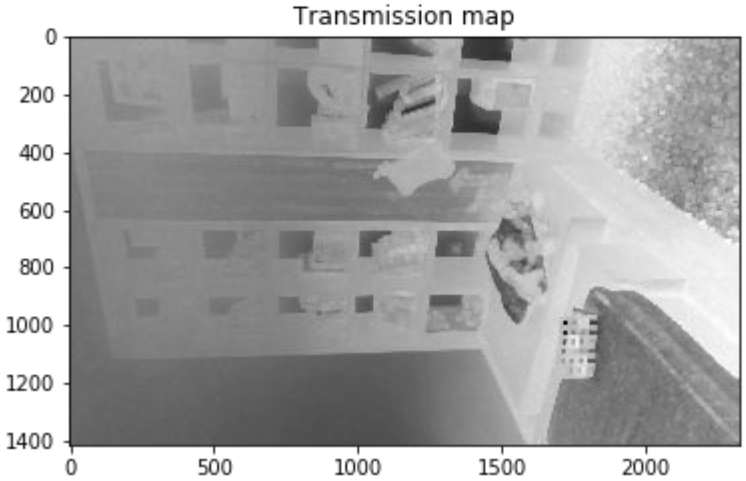
$$\mathbf{J}(\mathbf{x}) = \frac{\mathbf{I}(\mathbf{x}) - \mathbf{A}}{\max(t(\mathbf{x}), t_0)} + \mathbf{A}$$

Dehazing using deep channel prior

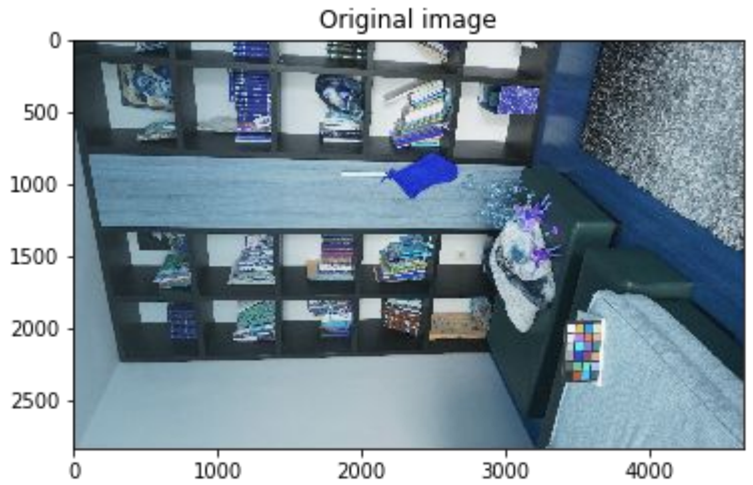


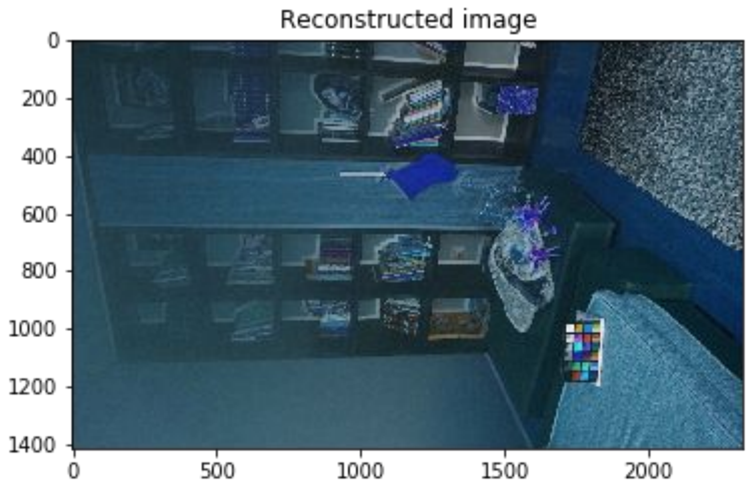


Dehazing using deep channel prior



Dehazing using deep channel prior





Thank You