Single Image Haze Removal Using Dark Channel Prior

AVD862 - Digital Image Processing
Literature review

By:
Saurabh Kumar (SC22B146)
Dipanshu Soni (SC22B128)

Haze

- Physical layer of white noise added to the image
- Suspended particles (dust, mist, fumes) scatter light
- Reduces contrast and visibility

Challenge of Haze Removal

- Outdoor images captured in bad weather (fog, haze, smog) suffer from low contrast, faint colors, and loss of detail

Haze Imaging Model

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

where

I(x): The Hazy Image (input)

J(x): The Clean Radiance (output/goal)

t(x): Transmission Map (how much light reaches the camera)

A: Atmospheric Light (color of the haze/sky)

- We only know I
- We need to find J, t and A
- 1 Equation, 3 Unknowns!

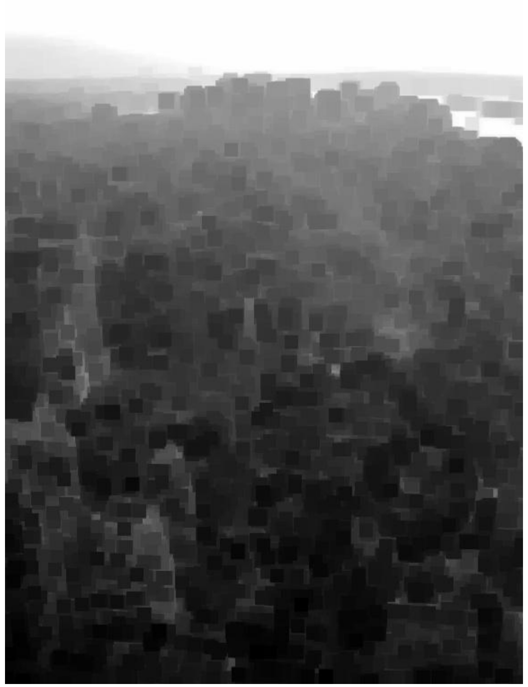
Dark Channel

- In non-sky patches of haze-free images, at least one color channel (R, G or B) has very low intensity (close to 0).

$$J^{dark}(x) \approx 0$$

- If a patch is not dark (>0), it must be due to Haze (whiteness)

  If t=1, no haze
  If t=0, totally opaque fog



Dark Channel Calculation

- Minimum filter:

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

At every pixel and its neighbours (15 x 15 window) and pick the lowest value among all colour channels (R, G, B) and all neighbours

- Using “erosion” as a local minimum filter

Atmospheric Light Estimation

- From dark channel, pick the top 0.1% brightest pixels, which represent the 'haziest' part of the image
- Select highest intensity pixel from original Image at those locations
- This gives A (Atmospheric Light)

Transmission Estimation

- Using the haze equation and the Dark Channel theory

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

ω = 0.95, a small amount of haze for depth perception

- **Refinement:**

- Min-filter creates blocky "halos" around edges
- Use **Guided Filter**: Acts as an edge-preserving smoothing filter

Image Recovery

- Using the original haze modelling equation:

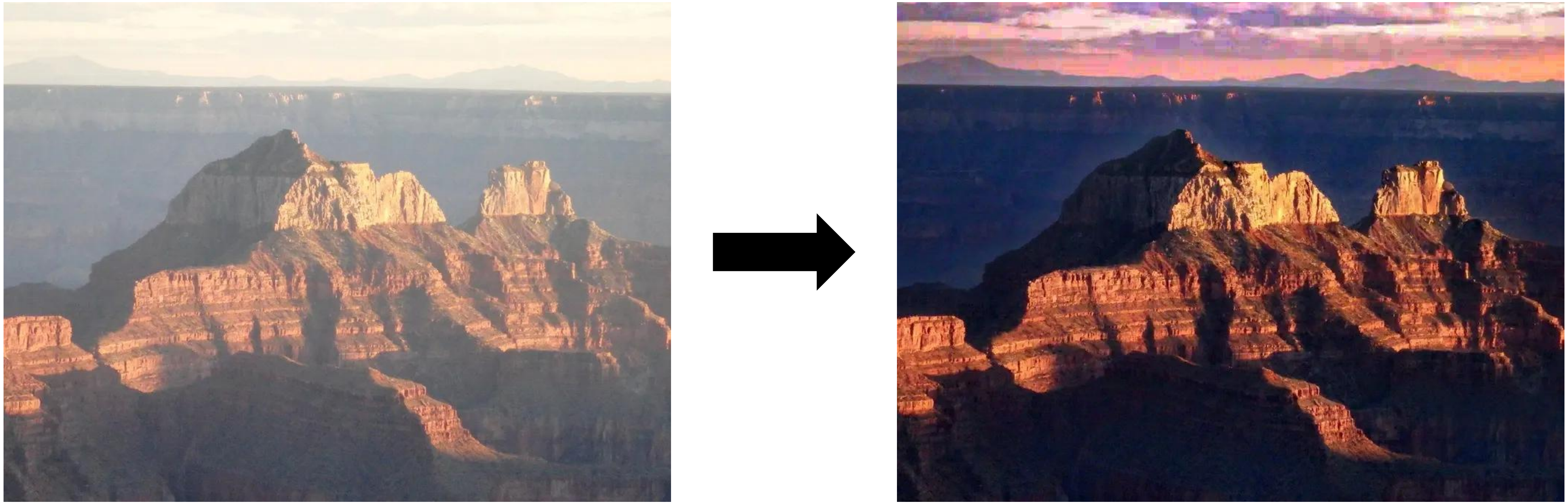
$$J(x) = \frac{I(x) - A}{\max(t(x), 0.1)} + A$$

- $\max(t(x), 0.1)$ is to prevent dividing by zero if transmission is extremely low

Demonstration

Demonstration

Demonstration



- **Paper Implemented**: Single Image Haze Removal Using Dark Channel Prior by Kaiming He, Jian Sun, and Xiaoou Tang (IEEE)
- **Paper Link**: https://ieeexplore.ieee.org/document/5567108
- **Python code on GitHub**: https://github.com/saurabhkr132/image-haze-remover

Thank You

☺