# Single Image Haze Removal Using Dark Channel Prior

Team4
r11943018 林子軒、r11943022 范詠為

# Outline

- Motivation
- Problem Definition
- Introduction
- Algorithm
- Expected Result
- Reference

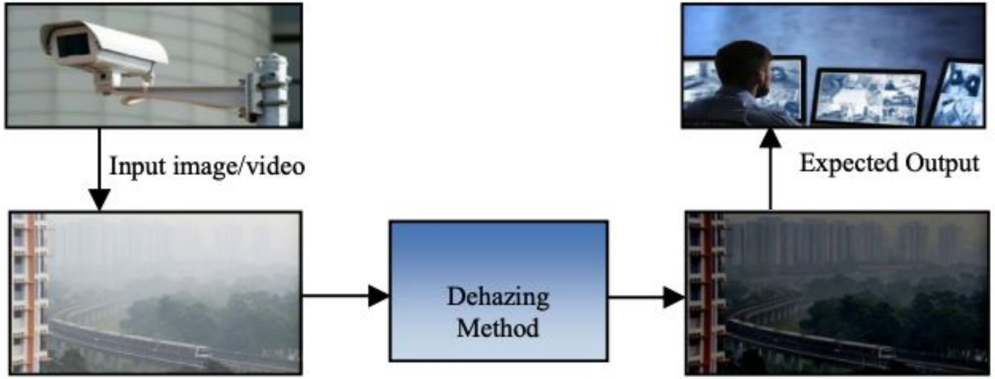
# Motivation

Haze removal can improve the quality of images, making them more useful for various applications

- **surveillance**
  - object detection & recognition
  - identification of people or vehicles
- **aerial photography**
  - the clarity of the terrain
  - detect changes or anomalies in the landscape
- **computer vision**
  - image classification, segmentation, or tracking
  - improve the accuracy

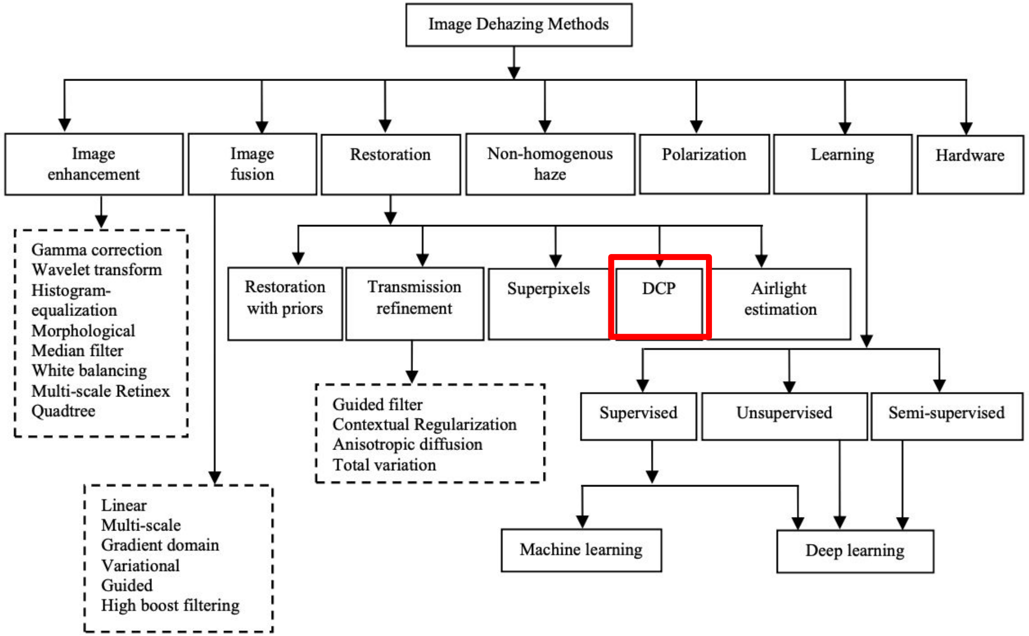
# Problem Definition

**Goal**: Produce a visually pleasing and natural-looking haze-free image that enhances the details and colors of the scene while preserving its overall appearance.



# Introduction

Different categories of image dehazing methods [2]



# Haze Imaging Equation

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

medium transmission

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

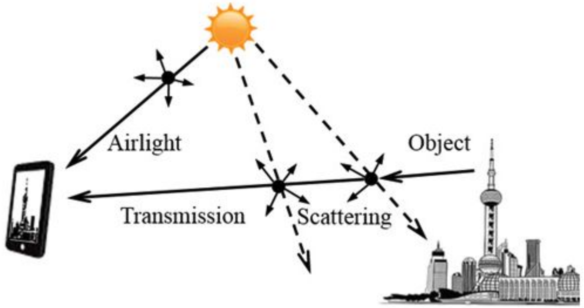
observed intensity

scene radiance

atmospheric light

hazy

haze-free



# Dark Channel Prior (DCP)[1]

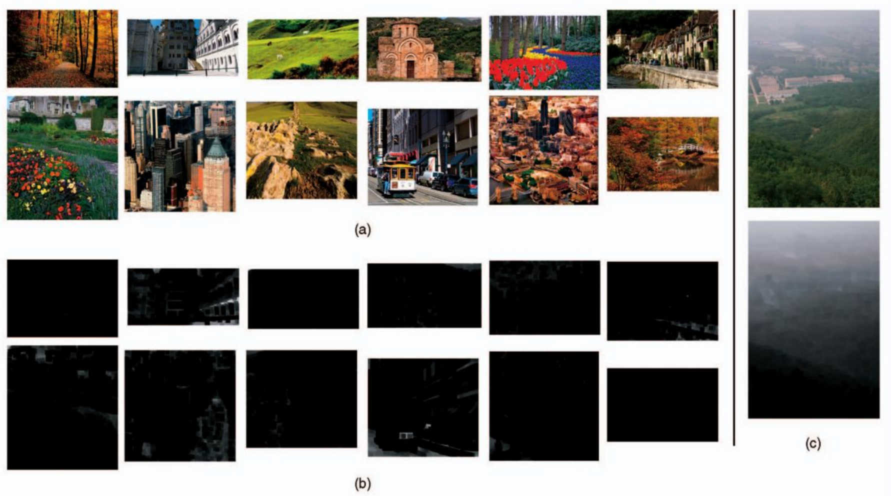
In outdoor haze-free images, pixels with low intensity in at least one RGB channel are commonly found in local regions not covering the sky.

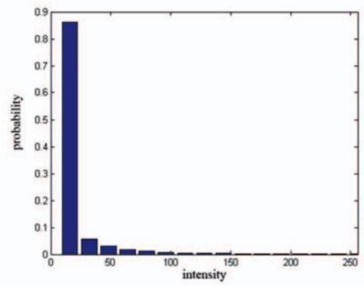
haze-free image dark channel

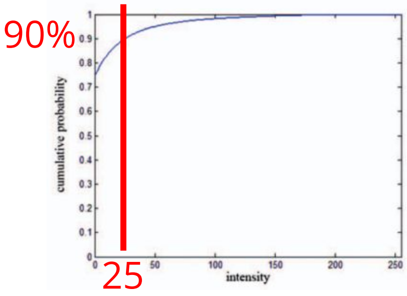
# Dark Channel Prior (DCP)[1]

Mainly result from three factors:

- shadows
- colorful objects or surfaces
- dark objects or surfaces



# Dark Channel Prior (DCP)[1]

$$J^{\mathrm{dark}}(\mathbf{x}) = \overset{\boxed{3}}{\underset{\mathbf{y}\in\Omega(\mathbf{x})}{\min}} \left( \overset{\boxed{2}}{\underset{c\in\{r,g,b\}}{\min}} \overset{\boxed{1}}{J^{c}(\mathbf{y})} \right)$$

**~ 0 if haze-free**

(a) (b) (c)

arbitrary image J — min of (r, g, b) — minimum filter (15x15)

1 — 2 — 3

# Algorithm

Input image **I(x)**

↓

Estimate atmospheric light **A**

↓

Acquire dark channel $\mathbf{J}_{\mathbf{dark}}\mathbf{(x)}$

↓

Calculate transmission **t(x)**

↓

Soft-matting

suppress halos and block artifacts

↓

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

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

$$\Downarrow$$

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

$$\Downarrow$$

$$\min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_c \frac{I^c(\mathbf{y})}{A^c}\right) = \tilde{t}(\mathbf{x}) \underbrace{\min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_c \frac{J^c(\mathbf{y})}{A^c}\right)}_{\mathbf{0}} + 1 - \tilde{t}(\mathbf{x}).$$

$$\Downarrow$$

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

# Expected Result - Qualitative

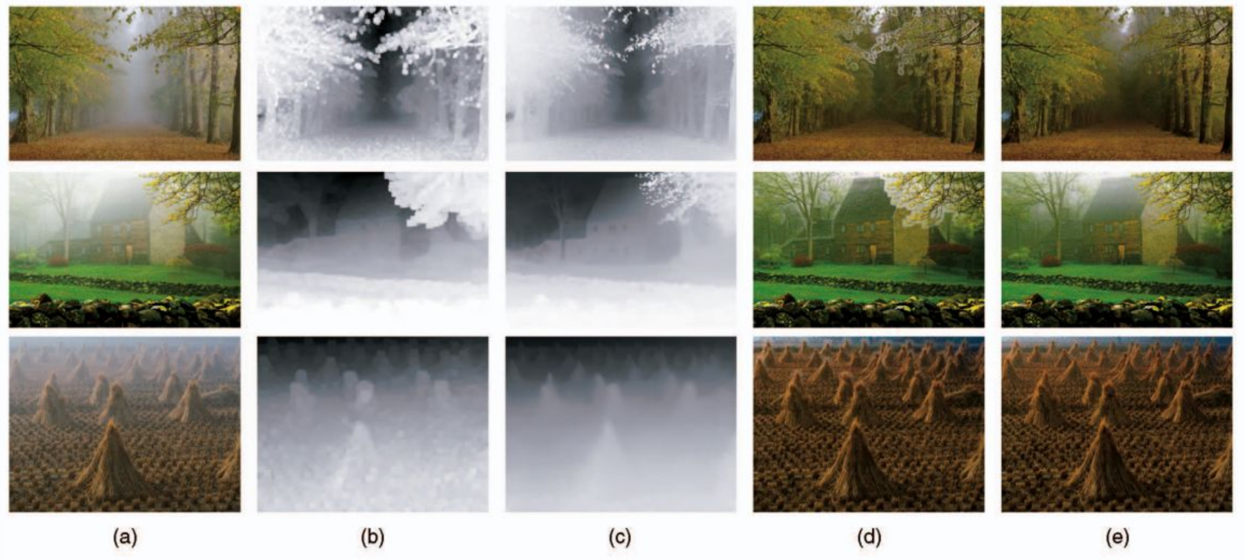


Fig. 6. Haze removal. (a) Input hazy images. (b) Estimated transmission maps before soft matting. (c) Refined transmission maps after soft matting. (d), (e) Recovered images using (b) and (c), respectively.

# Expected Result - Quantitative

Table 17 PSNR and SSIM comparison of existing techniques on RESIDE dataset

| Method | SOTS Outdoor | | SOTS Indoor | |
|---|---|---|---|---|
| | PSNR | SSIM | PSNR | SSIM |
| DCP [63] | 19.13 | 0.82 | 16.62 | 0.82 |

with ground-truth

Peak Signal-to-Noise Ratio (PSNR)

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right)$$

Structural Similarity Index (SSIM)

$$SSIM(r,i) = \left(\frac{2\mu_r\mu_i + c_1}{\mu_r^2 + \mu_i^2 + c_1}\right)\left(\frac{2\mu_{ri} + c_2}{\sigma_r^2 + \sigma_i^2 + c_2}\right)$$

# Reference

[1] He, Kaiming, Jian Sun, and Xiaoou Tang. "Single image haze removal using dark channel prior." *IEEE transactions on pattern analysis and machine intelligence* 33.12 (2010): 2341-2353.

[2] Agrawal, Subhash Chand, and Anand Singh Jalal. "A comprehensive review on analysis and implementation of recent image dehazing methods." *Archives of Computational Methods in Engineering* 29.7 (2022): 4799-4850.