A Comparative Study of Image Dehazing Algorithms

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What is Image Dehazing?

- Removing haze, fog, or similar atmospheric disturbances from an image.
- Aim is to counteract the effects of various atmospheric conditions which cause scattering of light resulting in reduced visibility, washed-out colours and lower contrast.

Cause of Haze in Images

- **Direct attenuation**
- **Airlight**

Components of Image Dehazing

Widely used model

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

- $I(x)$ = Observed hazy image intensity
- $J(x)$ = True scene radiance (haze-free image)
- $t(x)$ = Transmission map
- A = Global atmospheric light

When atmosphere is homogeneous, the transmission t can be expressed as

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

- β is the scattering coefficient of the atmosphere
- d is scene depth

Dark Channel Prior

In most non-sky patches, at least one colour channel has some pixels whose intensity are very low and close to zero.

For any arbitrary image J, its dark channel

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

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

This observation is called dark channel prior.

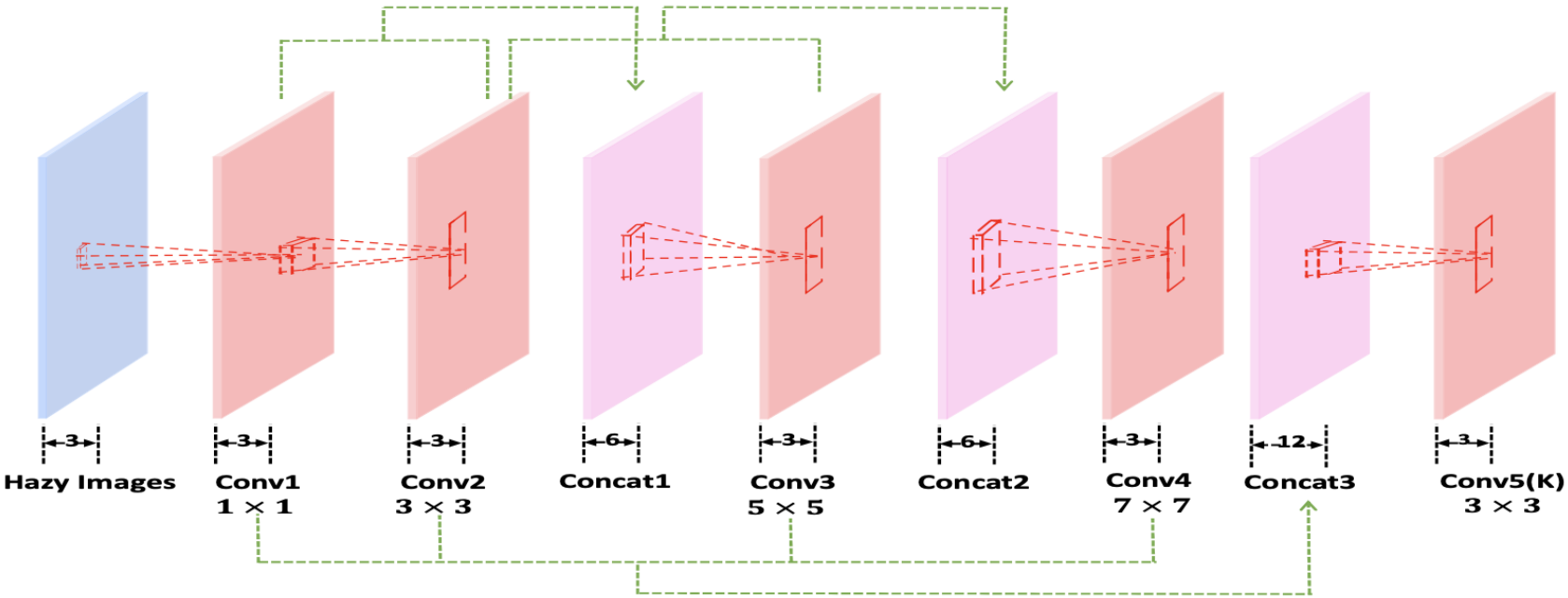
Steps of Haze removal using DCP

- Estimating the transmission map
- Soft matting
- Estimating the atmospheric light
- Recovering the scene radiance
- Patch size

All-In-One Dehazing Network

- Built with a convolutional neural network (CNN)
- Instead of estimating the transmission matrix and the atmospheric light separately, AOD directly generates the clean image
- Idea is to unify the two parameters $t(x)$ and A into one formula, i.e. $K(x)$ and directly minimize the reconstruction errors in the image pixel domain.
  $J(x) = K(x)I(x) - K(x) + b$
  where
  $K(x) = \frac{\frac{1}{t(x)}(I(x)-A)+(A-b)}{I(x)-1}$

All-In-One Dehazing Network - Network Design



K-estimation module of AOD-Net

Implementation and Training

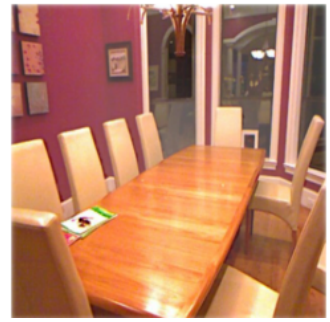
- Both the algorithms were implemented
- The AOD-Net was trained on NYU2 dataset of 27,256 images and took around 1.5 hours on an NVDIA 4050 GPU.
- Both the algorithms were tested on
  - SOTs indoor(50) and outdoor(500)
  - NH-Haze(55)
  - Smoke(12)

Analysis and Results

Hazy

Clean

DCP dehazed



AOD dehazed

Hazy

Clean

DCP dehazed

AOD dehazed

Analysis and Results (Contd.)

Hazy

Clean

DCP dehazed

AOD dehazed

Hazy

Clean

DCP dehazed

AOD dehazed

Comparison Metrics

PSNR	SOTs-I	SOTs-O	NH-Haze	Smoke
DCP	7.413	7.14	9.775	9.162
AOD-Net	18.99	19.60	12.17	11.73

SSIM	SOTs-I	SOTs-O	NH-Haze	Smoke
DCP	0.825	0.19	0.278	0.270
AOD-Net	0.8353	0.8916	0.2378	0.3865

Running Time(s)	SOTs-I	SOTs-O	NH-Haze	Smoke
DCP	0.5	0.40	1.78	0.55
AOD-Net	0.27	0.2	0.90	0.26