DIGITAL IMAGE PROCESSING

Single Image Haze Removal Using Dark Channel Prior

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CONTENT

INTRODUCTION

Background

- Deteriorated environment: Sandstorm, Dust and Haze
- Aerial surveying and mapping, Photography, Traffic information system and so on

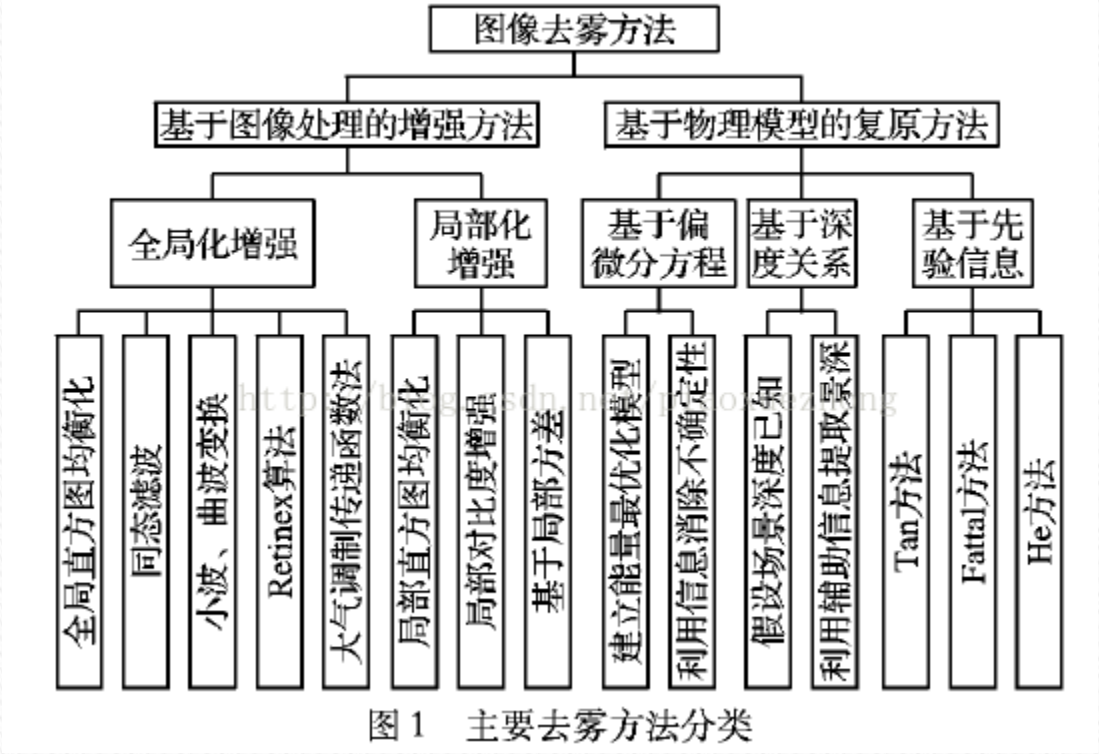


图 1　主要去雾方法分类

PRINCIPLE

Dark Channel Prior: $J^{\text{dark}} \to 0$

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

A model widely used in a hazy image:

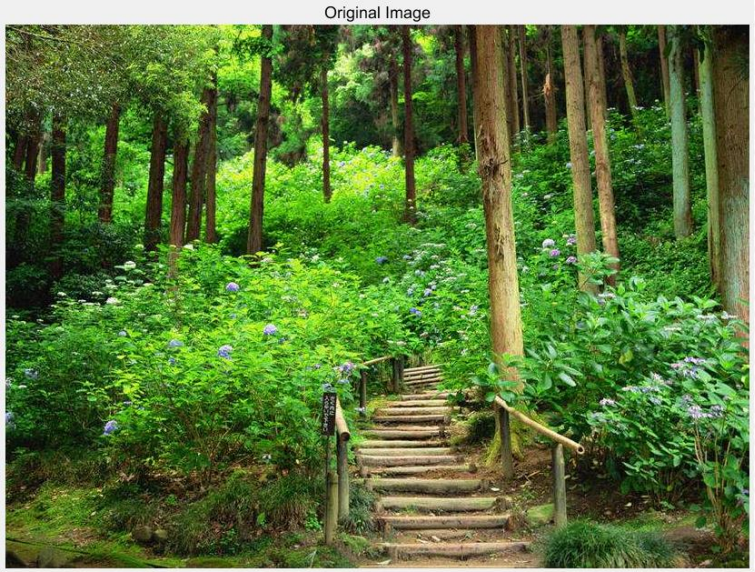
$$\mathbf{I}(\mathbf{x}) = \mathbf{J}(\mathbf{x})t(\mathbf{x}) + \mathbf{A}(1 - t(\mathbf{x}))$$

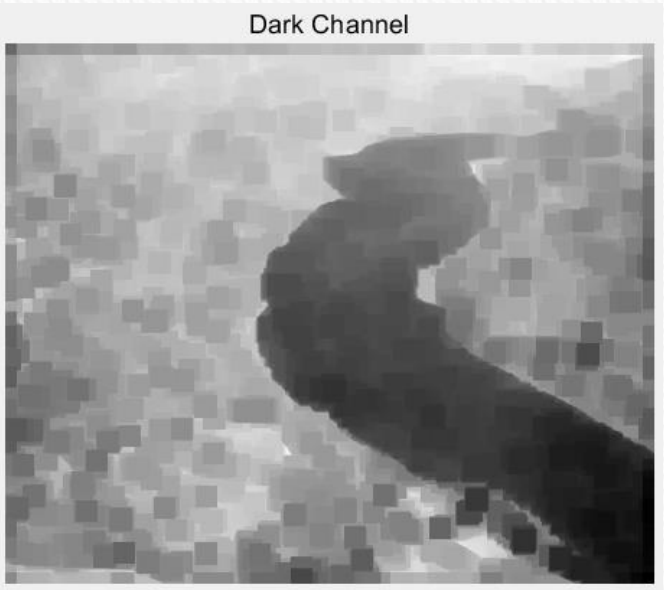
I: the observed intensity
J: the scene radiance
A: the global atmospheric light
t: the medium transmission

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

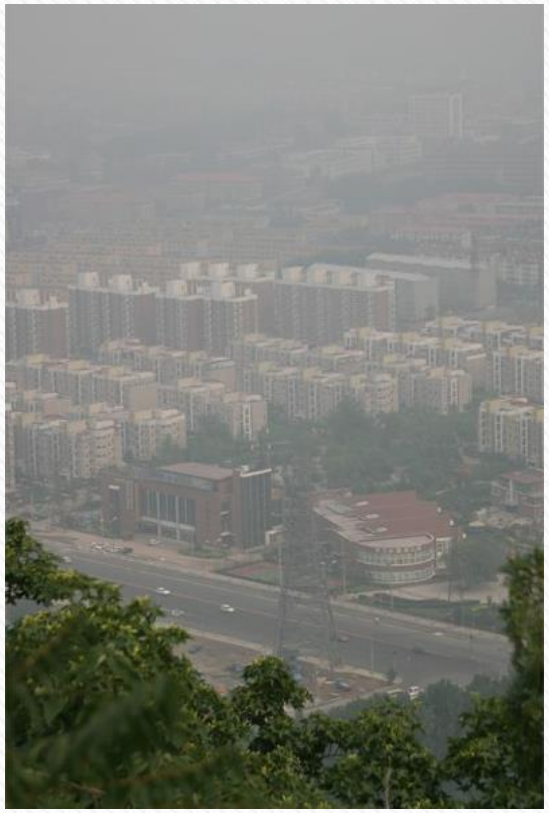
$$\tilde{t}(\mathbf{x}) = 1 - \min_{\mathbf{y}\in\Omega(\mathbf{x})} \left(\min_c \frac{I^c(\mathbf{y})}{A^c} \right)$$

A





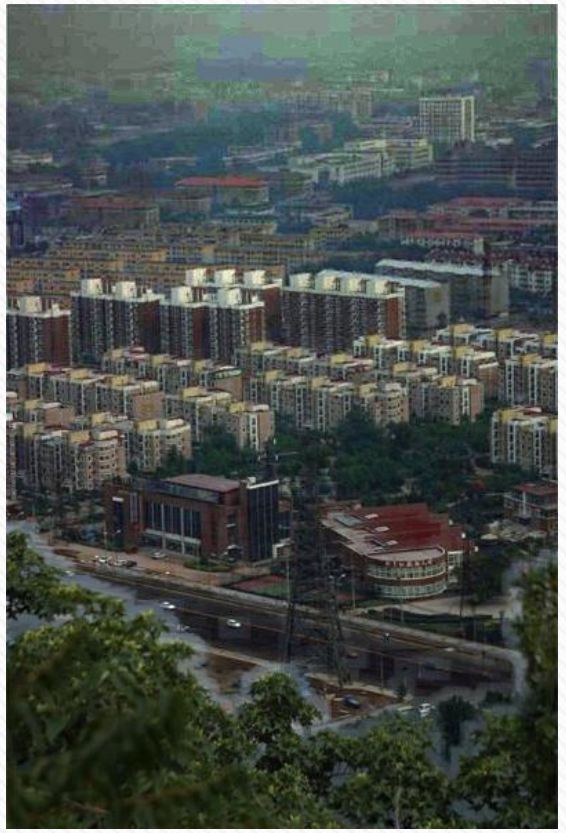
RESULT



Original Image

Dark Channel Prior

Transmission



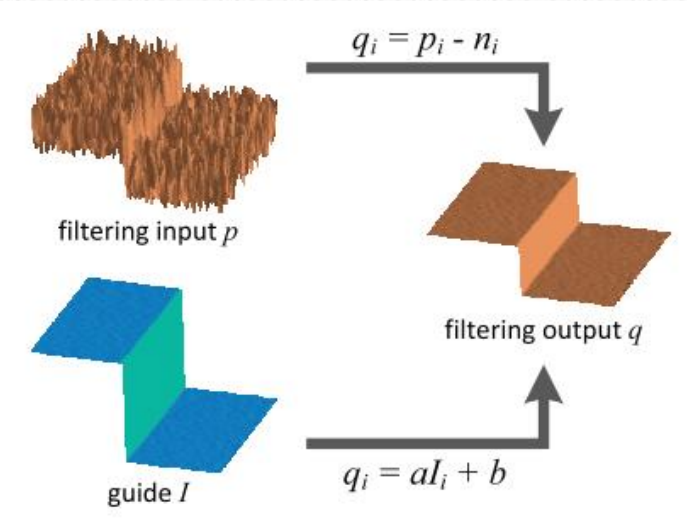
Haze Removed Image

IMPROVEMENT

Edge-preserving filter: Guided filter

Transmission

Transmission



Algorithm 1. Guided Filter.

Input: filtering input image p, guidance image I, radius r, regularization ϵ

Output: filtering output q.

1: $\text{mean}_I = f_{\text{mean}}(I)$
$\text{mean}_p = f_{\text{mean}}(p)$
$\text{corr}_I = f_{\text{mean}}(I .* I)$
$\text{corr}_{Ip} = f_{\text{mean}}(I .* p)$

2: $\text{var}_I = \text{corr}_I - \text{mean}_I .* \text{mean}_I$
$\text{cov}_{Ip} = \text{corr}_{Ip} - \text{mean}_I .* \text{mean}_p$

3: $a = \text{cov}_{Ip} ./ (\text{var}_I + \epsilon)$
$b = \text{mean}_p - a .* \text{mean}_I$

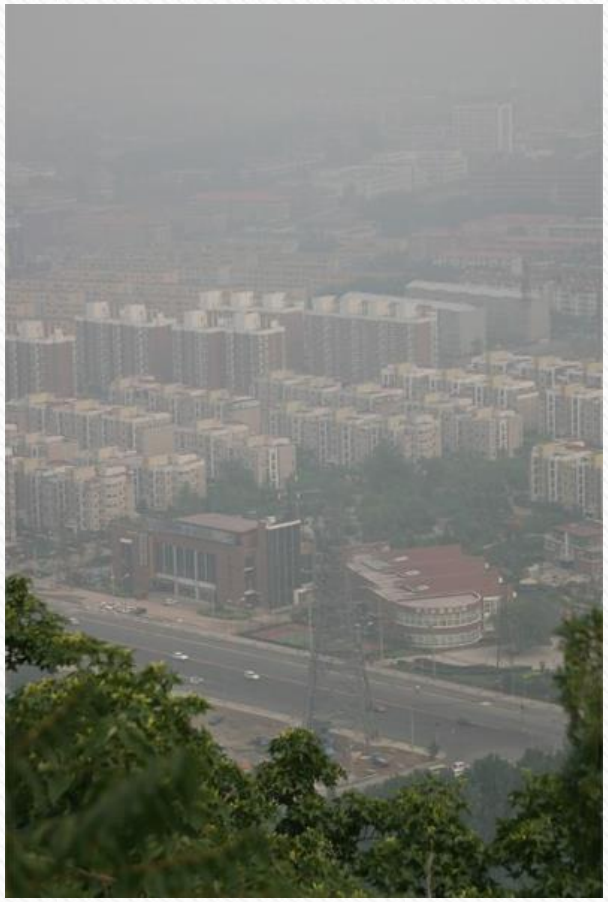
4: $\text{mean}_a = f_{\text{mean}}(a)$
$\text{mean}_b = f_{\text{mean}}(b)$

5: $q = \text{mean}_a .* I + \text{mean}_b$

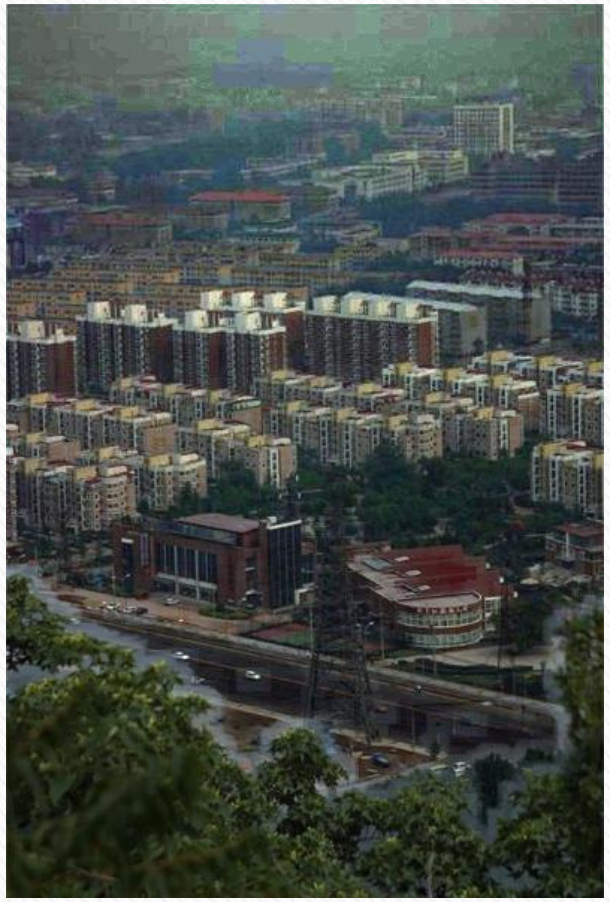
/* f_{mean} is a mean filter with a wide variety of O(N) time methods. */

IMPROVEMENT

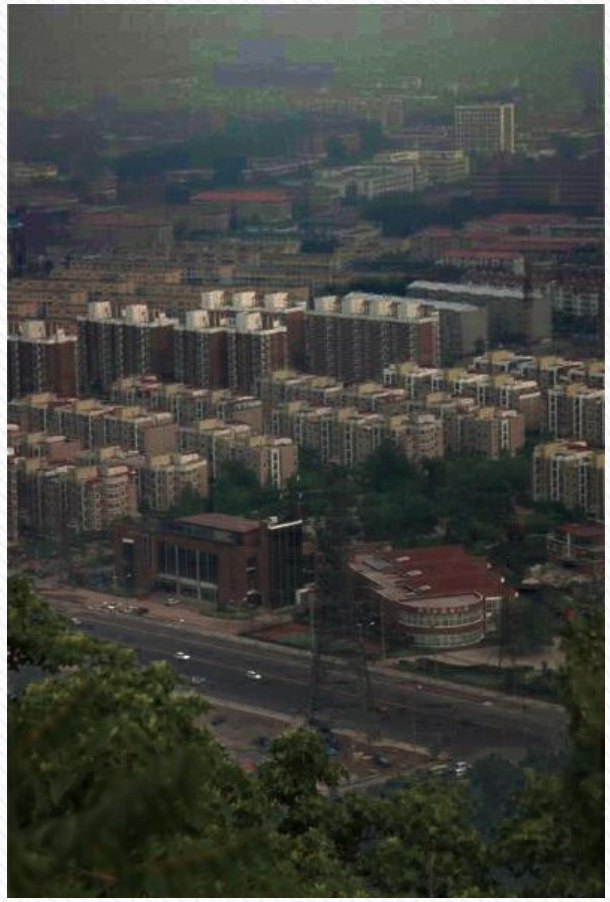
Edge-preserving filter: Guided filter



Original Image



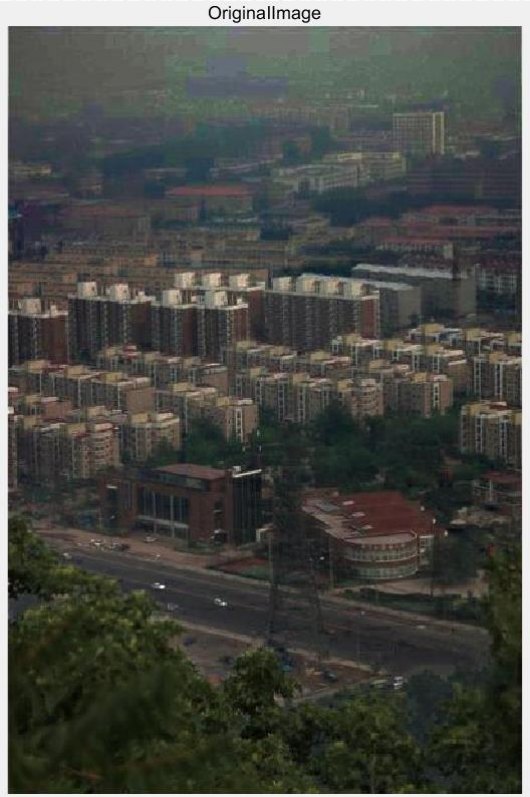
Without Filtering

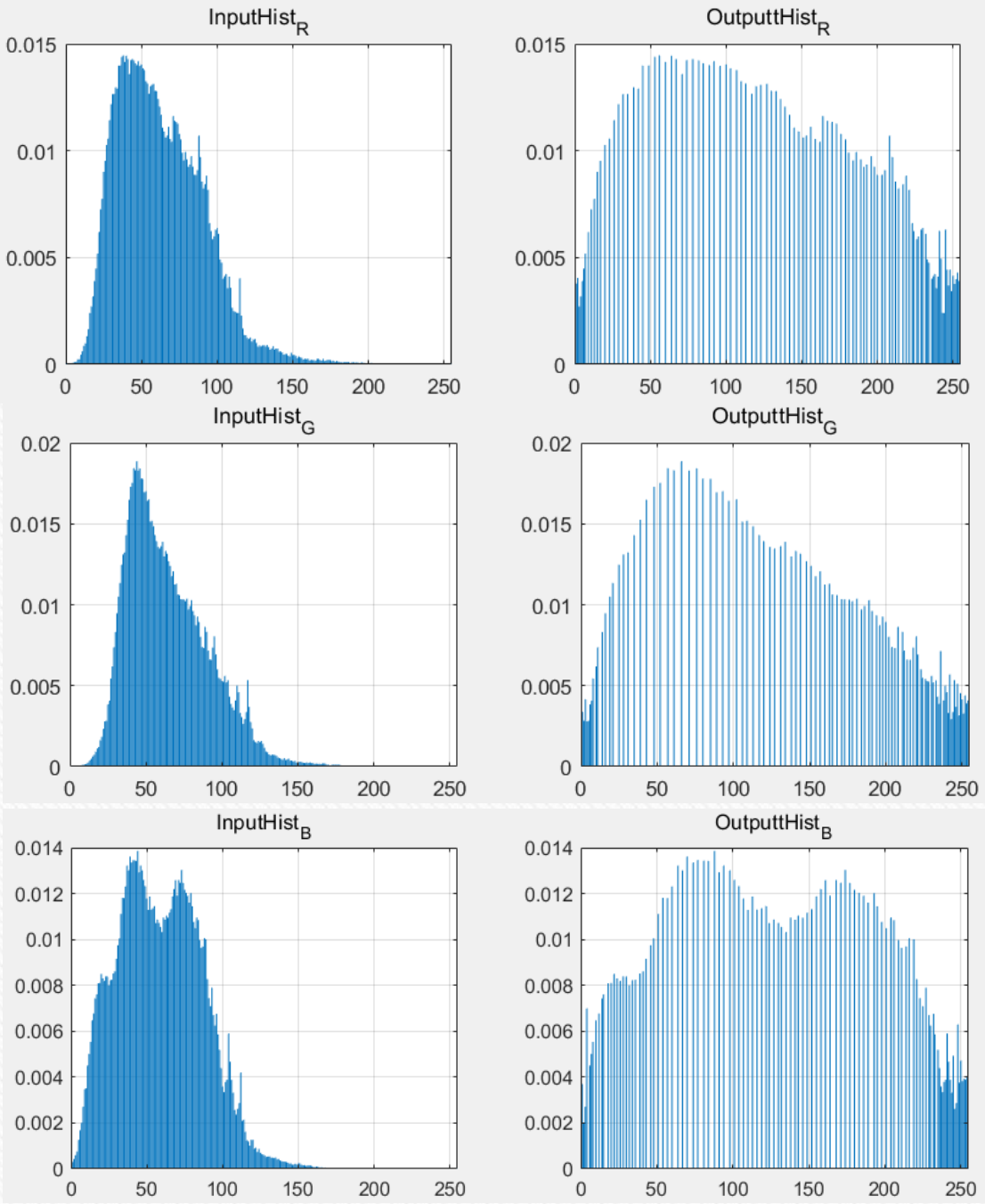


Guided Filtering

IMPROVEMENT

Brightness Adjustment: Histogram Equalization



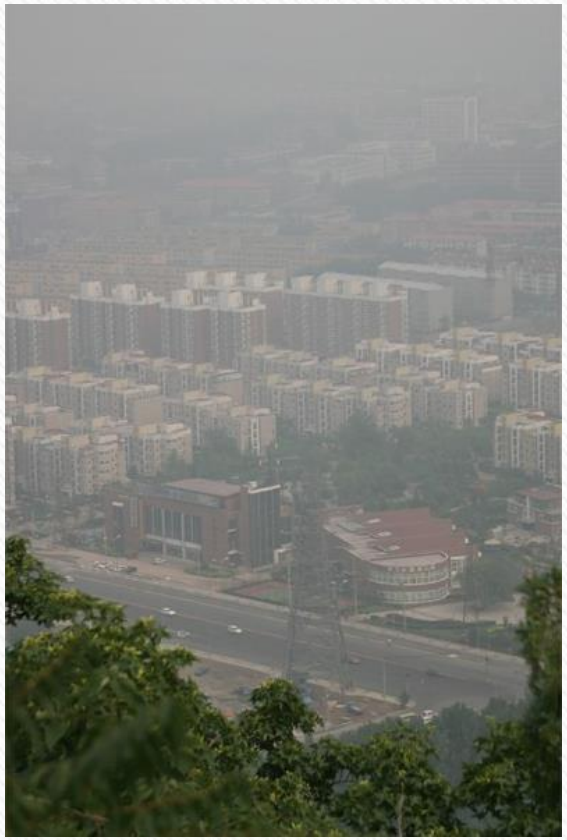


IMPROVEMENT

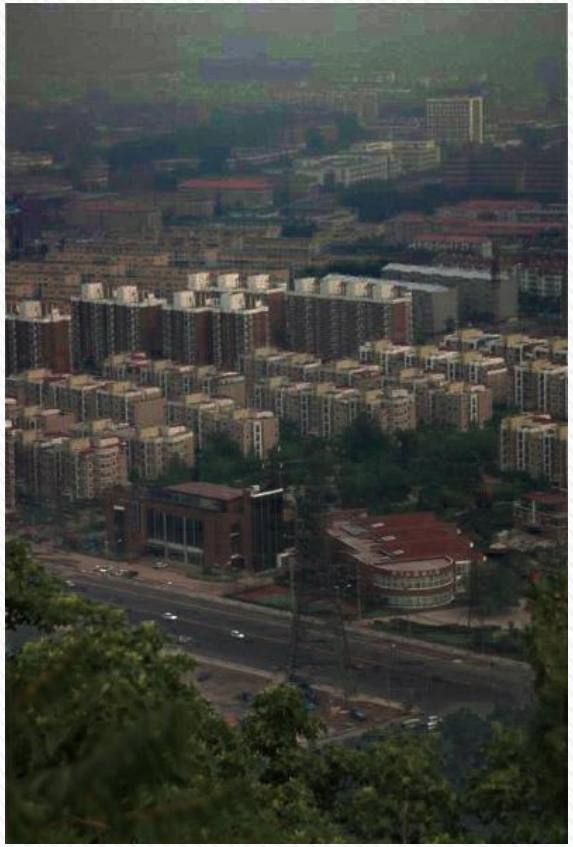
Brightness Adjustment:
Auto Color Gradation and Auto Contrast

```
if R0(i,j)<minR
    R(i,j) = 0;
elseif R0(i,j)>maxR
    R(i,j) = 255;
else
    R(i,j) = (R0(i,j)-minR)/(maxR-minR)*255;
end
```

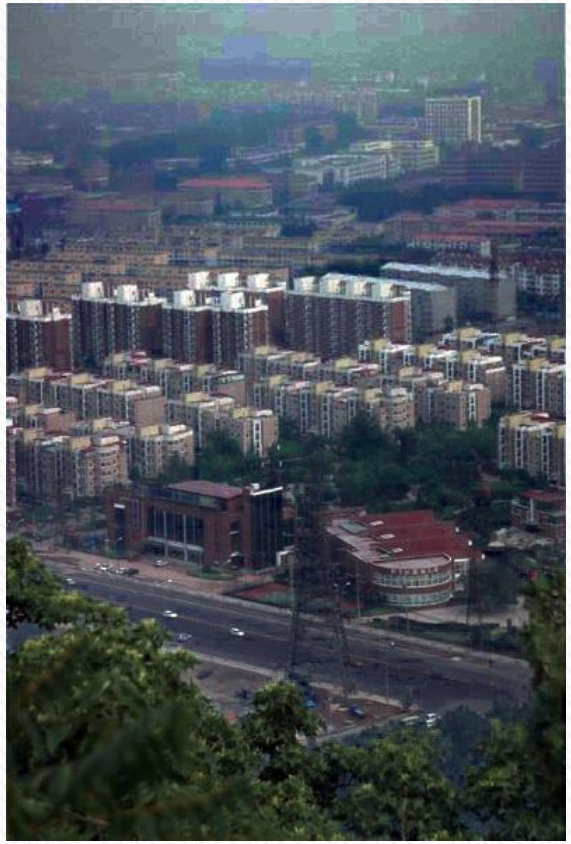
```
MIN = min([minR, minG, minB]);
MAX = max([maxR, maxG, maxB]);
```



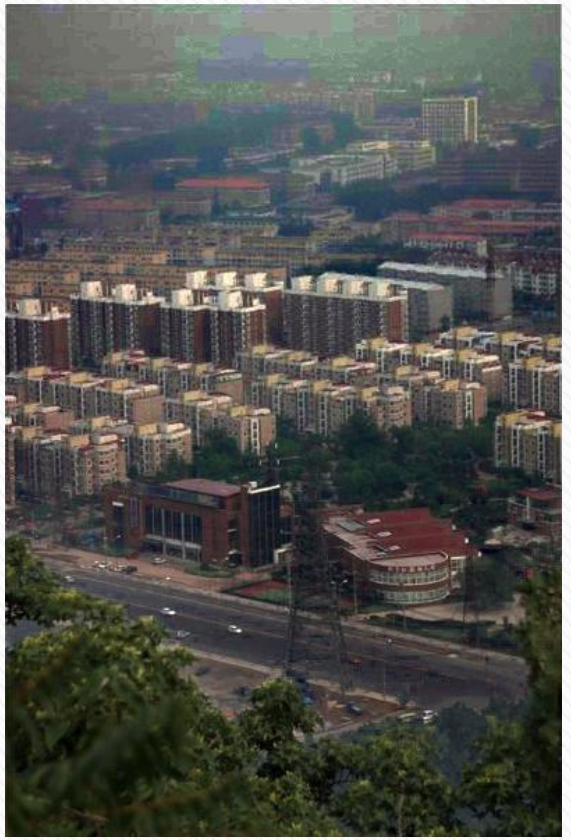
Original Image



Without Adjustment



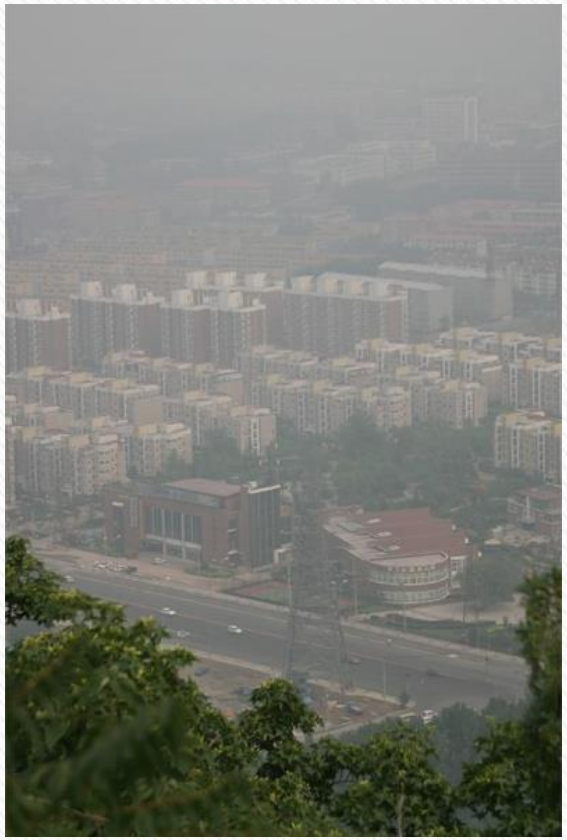
Auto Color Gradation



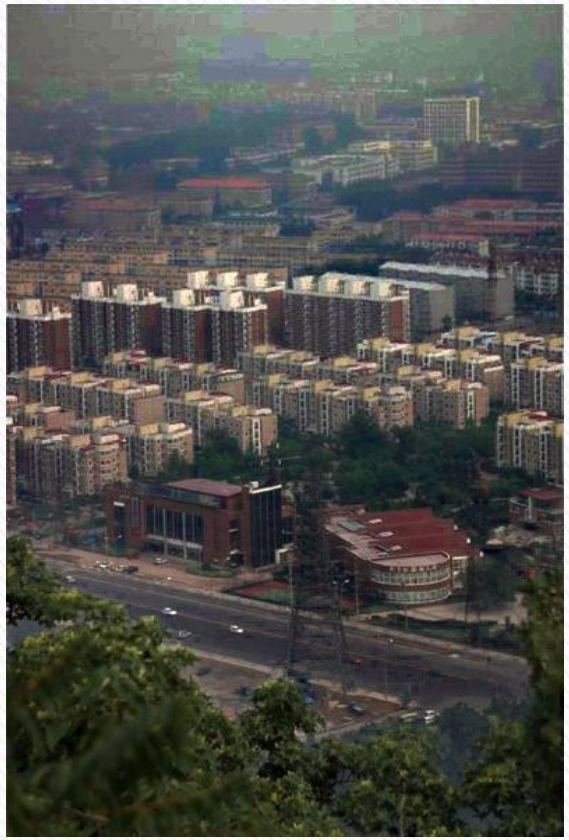
Auto Contrast

IMPROVEMENT

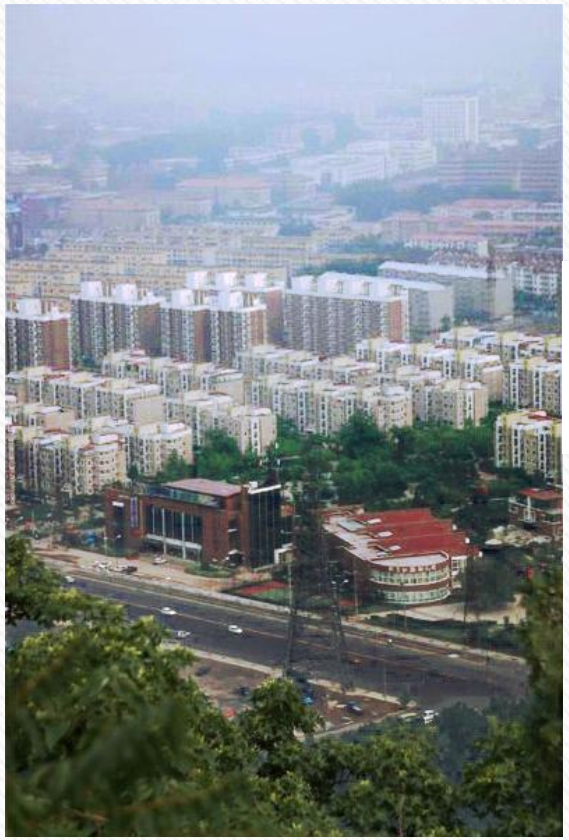
Sky Region Operation



Original Image



Auto Contrast



Sky Region Operation

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

$$J(x) = \frac{I(x) - A}{\min\left(\max\left(\frac{K}{|I(x) - A|}, 1\right) \bullet \max(t(x), t_0), 1\right)} + A$$

Comparison between I(x) and A:
|I(x) – A |> K → Normal Region
|I(x) – A |< K → Sky Region

MORE RESULTS

Original Image

MATLAB Image

Haze Removed Image

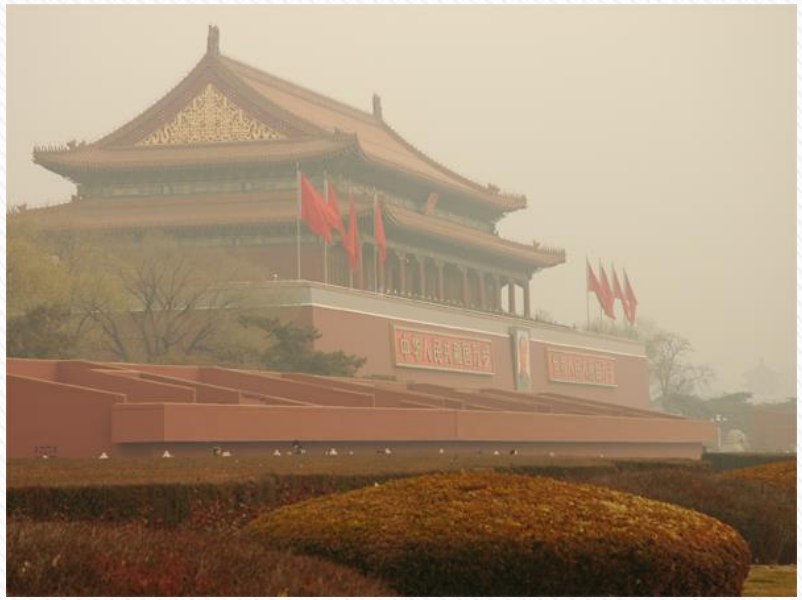
MORE RESULTS

Original Image

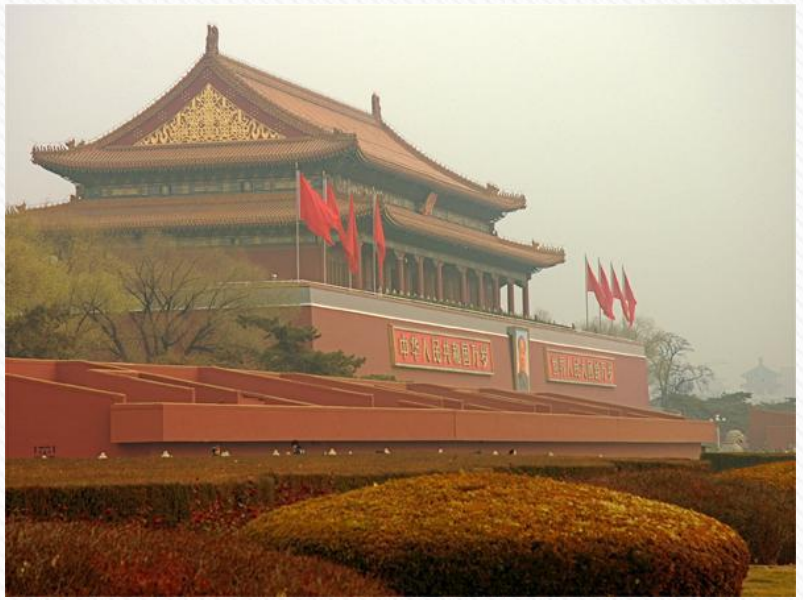
MATLAB Image

Haze Removed Image

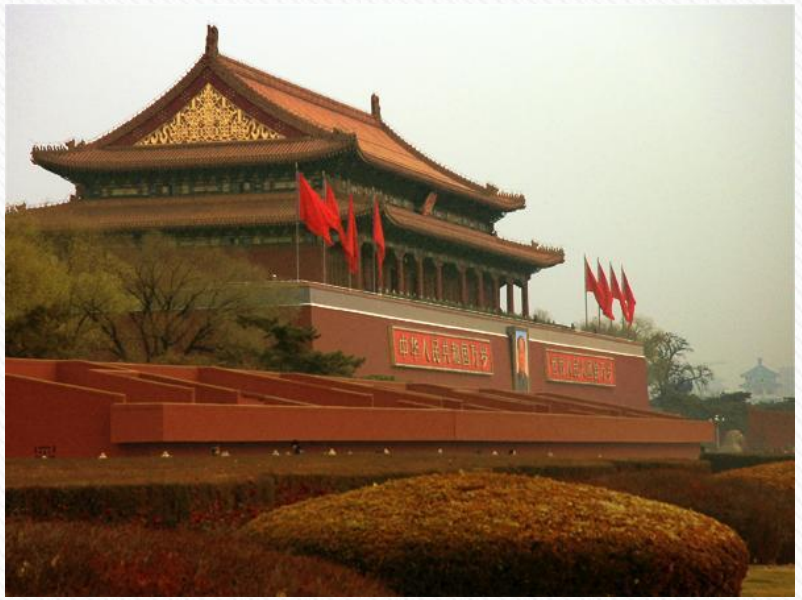
MORE RESULTS



Original Image



MATLAB Image



Haze Removed Image

REFERENCE

[1] Kaiming He, Jian Sun and Xiaoou Tang, "Single Image Haze Removal Using Dark Channel Prior", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 33, no. 12, pp. 2341-2353, 2011.
[2] Kaiming He, Jian Sun and Xiaoou Tang, "Guided Image Filtering", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 35, no. 6, pp. 1397-1409, 2013.
[3] "图像去雾算法（一）相关研究及链接 - CSDN博客", *Blog.csdn.net*, 2018. [Online]. Available: https://blog.csdn.net/piaoxuezhong/article/details/78301999. [Accessed: 05- Jun- 2018].
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