SINGLE IMAGE HAZE REMOVAL USING DARK PRIOR CHANNEL

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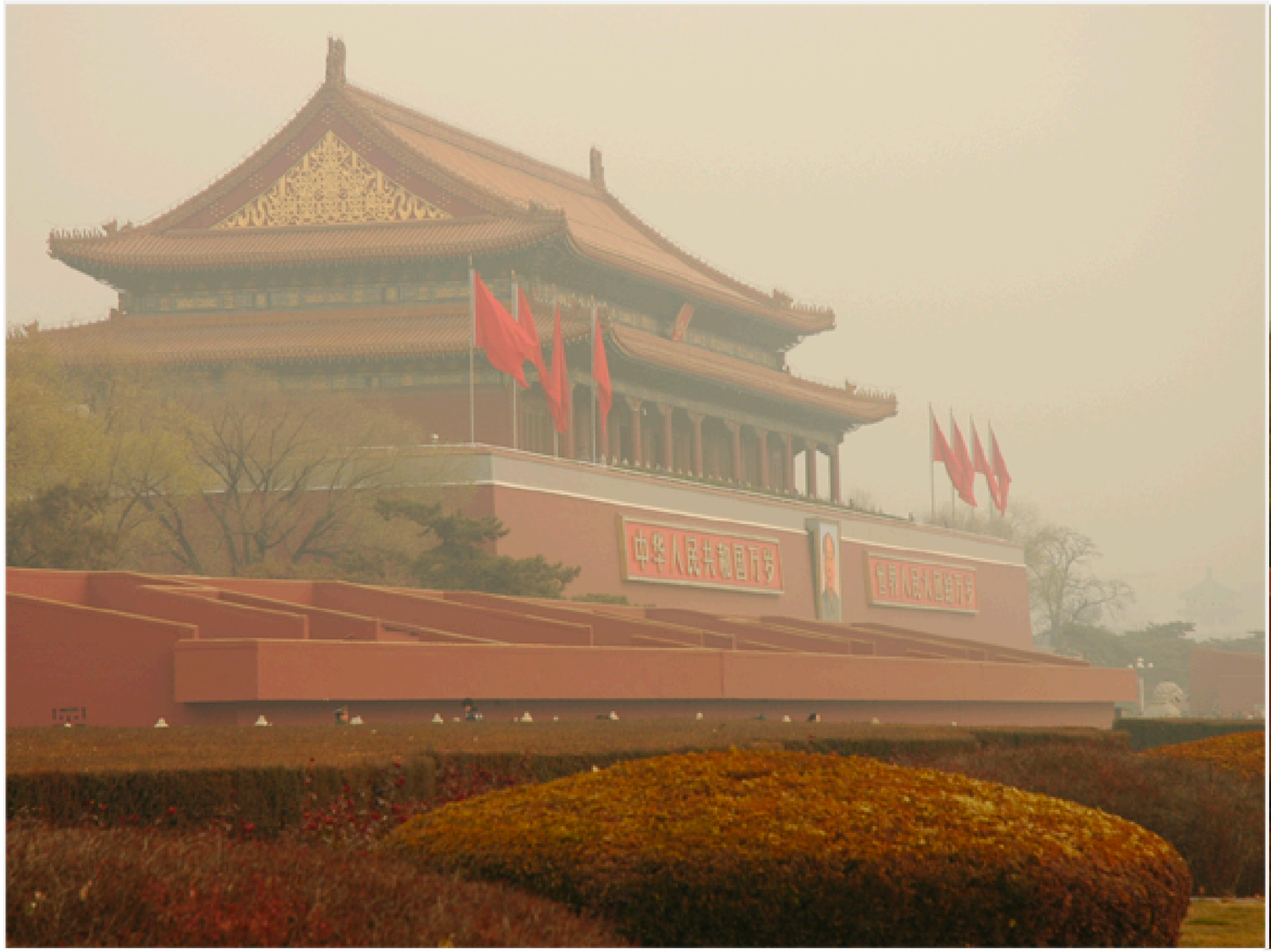
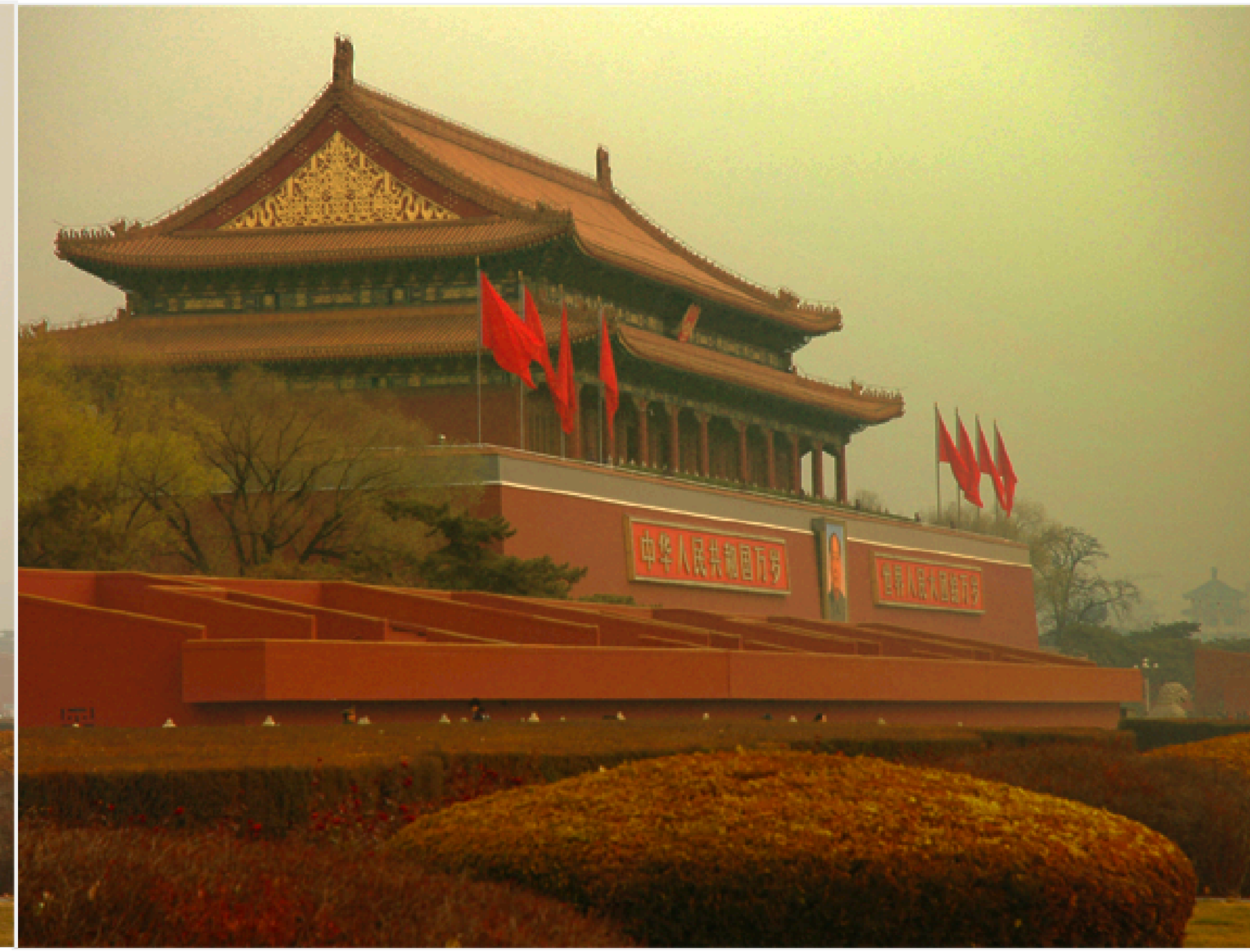


Hazy Image



Dehazed Image

Results

The resultant image is successfully dehazed

Hazy Image

Dehazed Image

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Hazy Image

Haze removal is an underconstrained problem if the input is only a single hazy image

Methods using multiple images or additional information exist

Dark Channel Prior

Our technique uses a dark channel prior for single image haze removal.

In most local regions which do not cover the sky, some pixels often have very low intensity in at least one color (RGB) channel. This knowledge can be used to create a dark channel prior

Estimated Transmission

The transmission describes the portion of light that is not scattered and reaches the camera.

Refined Transmission

Estimating the transmission produces some halos and block artifacts since transmission is not constant in a patch.

A guided filter is used to refine the transmission maps

Haze-free Output

Once we have the atmospheric light and the transmission map, we can recover the scene radiance

Definition of a Hazy Image

A haze image is typically modelled as

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

Here, I is the observed intensity, J is the scene radiance, A is the global atmospheric light and t is the transmission as defined earlier.

J(x)t(x) is direct attenuation and describes scene radiance and its decay in the medium

A(1-t(x)) is airlight resulting from previously scattered light and leads to shift in scene colors

Dark Channel Prior

For an arbitrary image J, its dark channel Jdark is given by

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

where Jc is a color channel of J and Ω(x) is a local patch centered at x.

Here, we use a patch size of 15 x 15.

Dark Channel Prior

In the dark channel prior, we will have dark regions where

1. There are shadows
2. The object is very colorful
3. The object is very dark

Hence in hazy regions, none of these apply and we have light regions in the dark channel prior.

Estimating the Transmission

The transmission may be estimated using the formula

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

where A is the atmospheric light and w is an adjustable parameter (0<w<=1) to let some amount of haze remain in the image for human convenience.

Estimating the Atmospheric Light

To estimate the transmission, we would require atmospheric light. Atmospheric light would be given by the brightest pixels in the image, since they would be the farthest.

However, bright objects may have brighter pixels than those in the distance thus we find the brightest pixels in the dark prior and locate those pixels in the original image.

The brightest pixel from this range depicts atmospheric light.

Soft Matting

We were following the paper written by He et al. and in the paper, the transmission is refined using soft matting.

While implementing soft matting, however, we ran into the difficulty of this function requiring large computing power and lots of time.

We searched for an alternative to soft matting and discovered a guided filter which worked much more efficiently than the proposed soft matting approach.

Guided Filter

The guided filter requires an input image along with a guidance image and gives an output which is a linear transform of the guidance image.

This filter has two advantages:

1. Edge-preserving smoothing property

2. No gradient reversal artifacts

Recovering Scene Radiance

Upon achieving the refined transmission map and having the atmospheric light component, the final scene radiance J(x) can be recovered by the formula

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

When t(x) -> 0, J may become prone to noise thus we restrict the transmission t(x) by a lower bound t0 and preserve a small amount of haze in very dense haze regions


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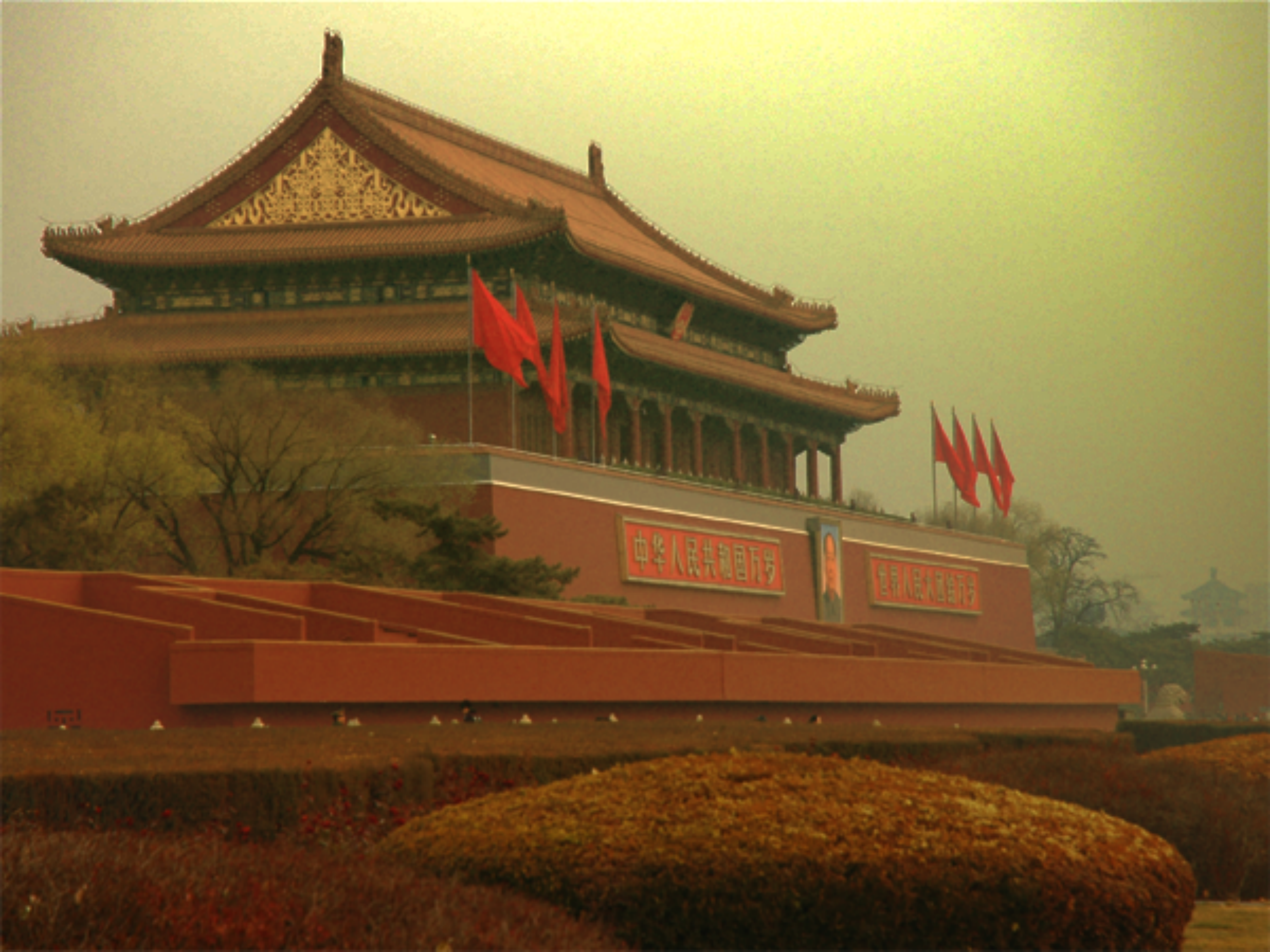

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References

- Kaiming He, Jian Sun & Xiaoou Tang, "Single Image Haze Removal Using Dark Channel Prior", Transactions on Pattern Analysis and Machine Intelligence (TPAMI) 2011

- Kaiming He, Jian Sun & Xiaoou Tang, "Guided Image Filtering", Transactions on Pattern Analysis and Machine Intelligence (TPAMI) 2013