Local Gray World Method for Single Image Dehazing

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Haze model

Haze degradation equation:

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

With parameter t defined as:

$$t = e^{-\beta d}$$

Parameter	Description
I	Observed image
J	Ground truth image
A	Haze color (also known as airlight)
t	Transmission map
β	Haze density parameter
d	Distance of point from camera

Table: Description of all parameters in the haze model

Gray world assumption

A standard color constancy assumption that, on average, the world is gray

$$\sum_{x} I_R(x) = \sum_{x} I_G(x) = \sum_{x} I_B(x)$$

Sometimes with additional strogner assumption

$$\frac{1}{N}\sum_{x} I_R(x) = \frac{1}{N}\sum_{x} I_G(x) = \frac{1}{N}\sum_{x} I_B(x) \approx \frac{1}{2}$$

Local variant

$$\forall y : \frac{1}{|\Omega|}\sum_{x\in\Omega_y} I_R(x) = \frac{1}{|\Omega|}\sum_{x\in\Omega_y} I_G(x) = \frac{1}{|\Omega|}\sum_{x\in\Omega_y} \approx \frac{1}{2}$$

Parameter estimations

We can estimate $\boldsymbol{A}$ from the darkest channel of brightest pixels in the image. we do this by taking 1% percent of pixels with brightest dark channel, and the picel with highest intensity of these chosen pixels is the approximate color of airlight $\boldsymbol{A}$.

$$\boldsymbol{A} = \max_{I(x)\in \text{centile}(I_m(x),1)} I(x) \qquad (1)$$

We can get a rough estimate of t using the local gray world assumption for the clear image and assuming local constancy of t

$$\frac{1}{|\Omega|}\sum I(x) = t\frac{1}{|\Omega|}\sum J(x) + (1 - t)\boldsymbol{A}$$

$$\frac{1}{|\Omega|}\sum I(x) = \frac{1}{2}t + (1 - t)\boldsymbol{A}$$

So formula for t is

$$t = \frac{\frac{1}{|\Omega|}\sum I(x) - \boldsymbol{A}}{\frac{1}{2} - \boldsymbol{A}} \qquad (2)$$

Guided image filtering

Once the rough estimate of t is obtained we need to smooth it, while respecting the edges of original image.

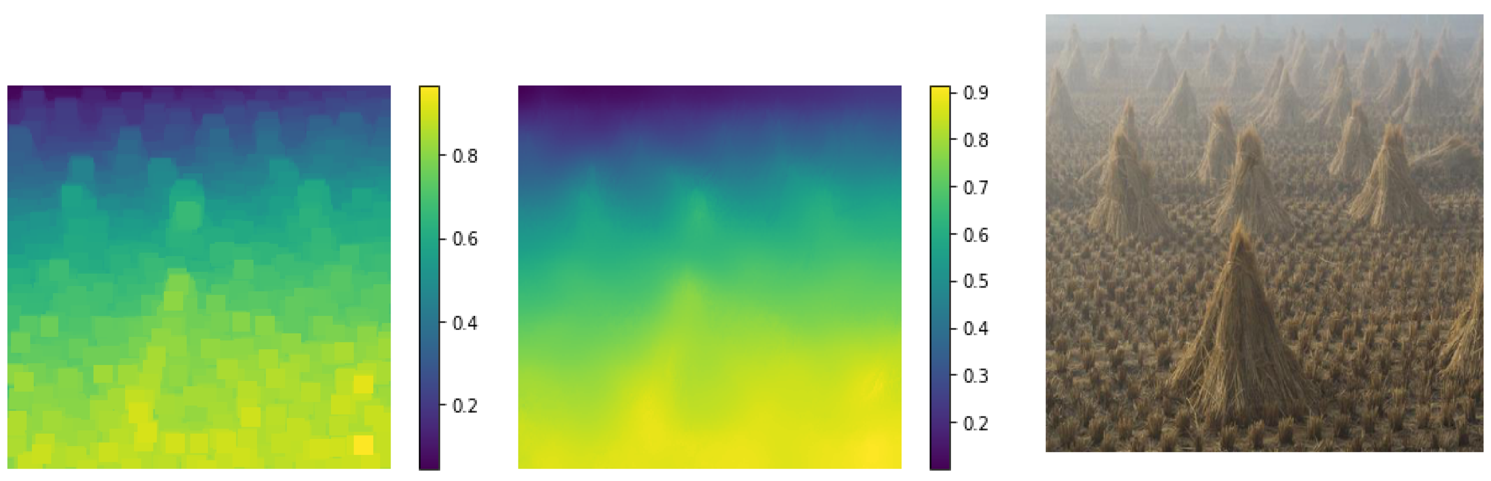

Figure: Example of, from left and right, a blocky estimate of t, its refined version and the hazy image used as the guide

Algorithm

1. Estimate $\boldsymbol{A}$ using (1)
2. Estimate t using (2)
3. Smooth out t using guided image filtering
4. Reconstruct $\boldsymbol{J}$ from $\boldsymbol{I}$ using estimated $\boldsymbol{A}$ and t

Results

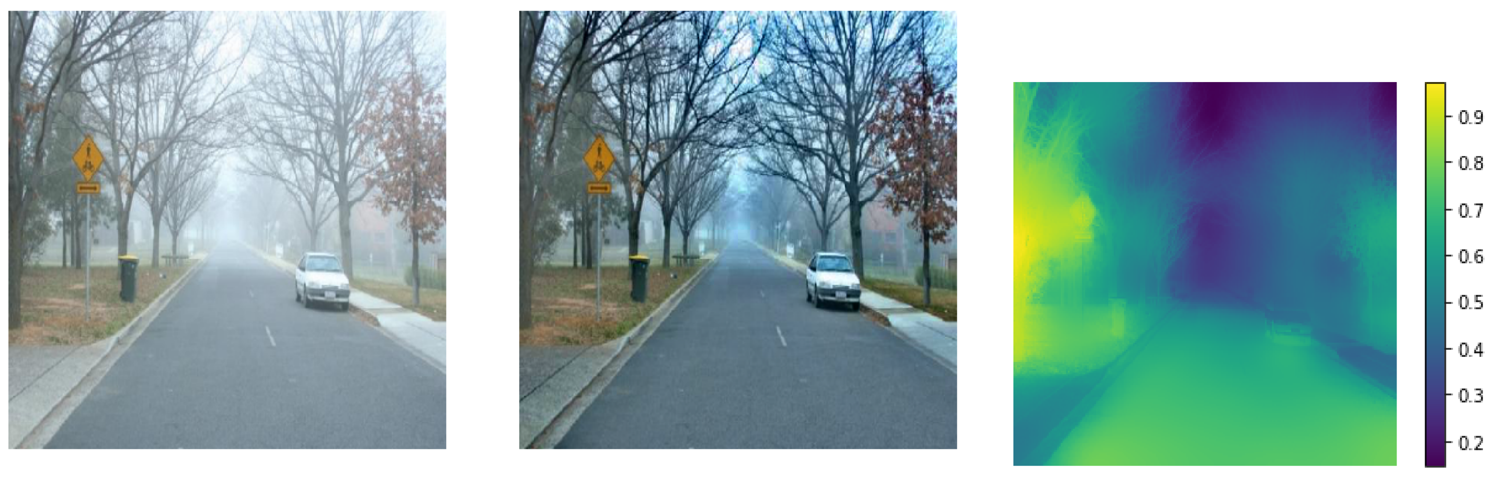

Figure: Example of local gray world single image dehazing method applied to a real world hazy image that conforms to the prior relatively well. Left to right: Original image, dehazed image and estimated transmission map t.

Figure: Example of local gray world single image dehazing method applied to a real world hazy image that does not conform to the prior too well. Left to right: Original image, dehazed image and estimated transmission map t.

Effects of airlight estimation

Figure: Top line shows the original hazy image (left) and the pixels included in estimation of airlight parameter $\boldsymbol{A}$ (right). The bottom image shows the dehazed images using the estimated, incorrect, $\boldsymbol{A}$ on the left, and a better value set by hand on the right.

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