Single Image Haze Removal Using Dark Channel Prior

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1. Haze Removal Using Dark Channel Prior

1.1. Estimating the Transmission

Haze imaging equation

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

As before,in a very small eare,author assume transmission t(x) is constant and denote this as $\widetilde{t}(x)$

$$\widetilde{t}(x) = 1 - \min_{y\in\Omega(x)} \left(\min_{c} \frac{I^c(y)}{A^c} \right) \tag{2}$$

But in the real world, even in clear day,there are haze in atmosphere,so author change the equaiton 2,adding a weight $\omega(0 < \omega \leq 1)$ to control the haze

$$\widetilde{t}(x) = 1 - \omega \min_{y\in\Omega(x)} \left(\min_{c} \frac{I^c(y)}{A^c} \right) \tag{3}$$

Going further to generalize equation 1,we can get a new equation

$$\mathbf{I}(x) = \mathbf{J}(x)t_1(x) + \mathbf{A}(1 - t_2(x)) \tag{4}$$

From the befor work we can get the transmission $t_2(x) = \widetilde{t}(x)$,the only problem is reduced to a multiplicative form $\mathbf{J}(x)t_1(x)$.And author say there are other way to disentangle this term,but he din't give.Fig 1(b) shows the estimated transmission maps using equation (2). Fig. 1(d) shows the corresponding recovered images. As we can see,the main problems are some halos and block artifacts. This is because the transmission is not always constant in a patch.For this problem,author propose a soft matting method to refine the transmission maps.

1.2. Soft Matting

The image matting equation

$$\mathbf{I} = \mathbf{F}\alpha + \mathbf{B}(1 - \alpha) \tag{5}$$

we can notice that the haze imaging equation(1) has very similar form as equation(5).A transmission map in the haze imaging equation is exactly an alpha map. So author apply a closed-form framework of matting [1] to refine the transmission.In the middle work,I don't understand.FInally,author perform a bilateral filter [2] on t to smooth its small scale textures.Fig. 1(c) shows the refined results using Fig. 1(d) as the constraint.

1.3. Recovering the Scene Radiance

Now we have figured out A and t(x),so based on equation (1),we can comepute J(x),but when t(x) is closed to zero,the J(x) is prone to noise.So author proposed a lower bound t_0 to restrict the transmission t(x).The final scence radiance J(x) is recovered by

$$\mathbf{J}(x) = \frac{\mathbf{I}(x) - \mathbf{A}}{max(t(x), t_0)} + \mathbf{A} \tag{6}$$

And t_0 is given 0.1.

1.4. Patch Size

A key parameter in this algorithm is the patch size in eqation 2. From Fig. 2.The larger the patch size, the darker the dark channel.And if the patch size is to small,the picture you recover will be oversaturated.Biger is good,not too small.

References

[1] A. Levin, D. Lischinski, and Y. Weiss. A closed form solution to natural image matting. *Proc. IEEE Conf. Computer Vision and Pattern Recognition*, 1:61–68, 2006. 1

[2] C. Tomasi and R. Manduchi. Bilateral filtering for gray and color images. *Proc. Sixth IEEE Intl Conf. Computer Vision*, 1:839, 1998. 1

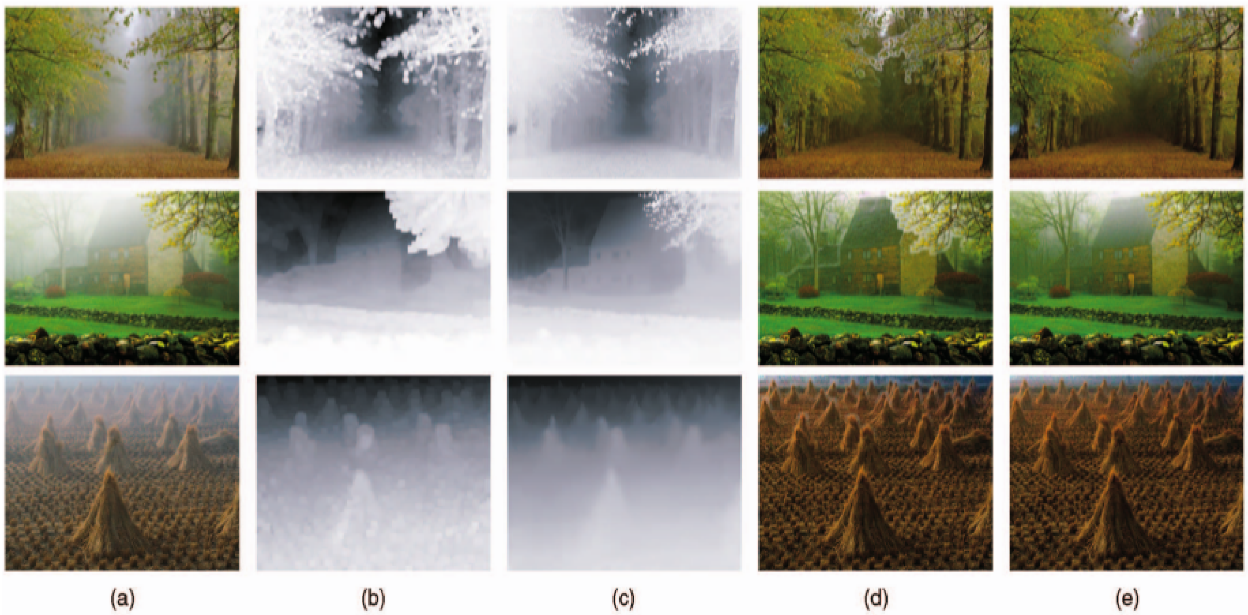

Figure 1. Haze removal. (a) Input hazy images. (b) Estimated transmission maps before soft matting. (c) Refined transmission maps after soft matting. (d), (e) Recovered images using (b) and (c), respectively.

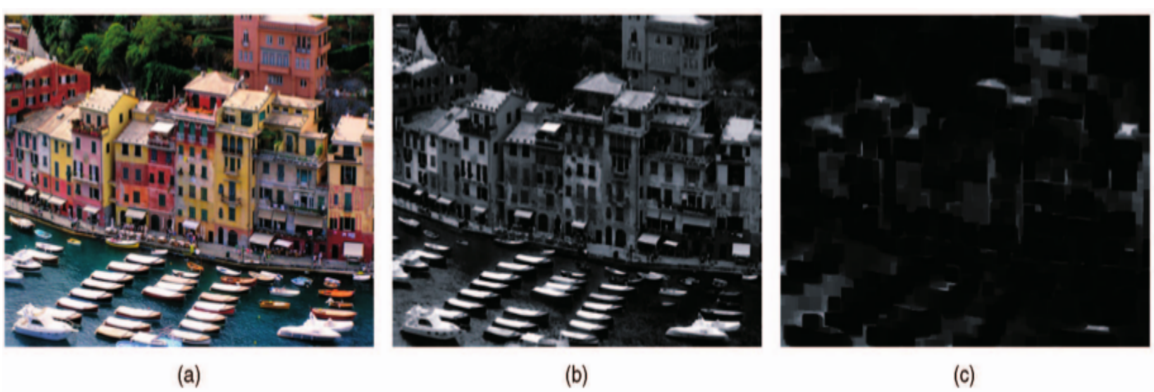

Figure 2. A haze-free image (600×400) and its dark channels using 3×3 and 15×15 patches, respectively.