Improved reflection removal with dark channel prior

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ABSTRACT

This article proposed an idea that the quality of reflection removal can be improved by preprocess the input image with a dehaze method (which is dark channel prior in this paper).

INTRODUCTION

Dark channel prior is a dehaze algorithm that proposed by He kaiming [1] in 2009. Recently I found that when we try to remove reflection from real life images with reflection removal algorithm (learning or non-learning), we can get a better result if we preprocess the inputs with dark channel prior. In this paper we will briefly discuss why the dark channel can help to remove the reflection.

HOW CAN A DEHAZE METHOD WORKS ON REFLECTION REMOVAL?

Generally, there are two types of reflection existed: specular reflection, where the incident light is reflected into a single outgoing direction, and diffuse reflection, where incident light is reflected into a different outgoing direction (fig 1). The diffusion reflection will globally increase brightness of the reflection and lower its clearness (fig 2-1), which looks very similar to fog. That is why we can use a fog removing method to remove the diffusion reflection (fig 2-2). Since dark channel will increase the saturation and lower the brightness of input image, we increase the brightness all the result by 10% and lower its saturation by 20%.

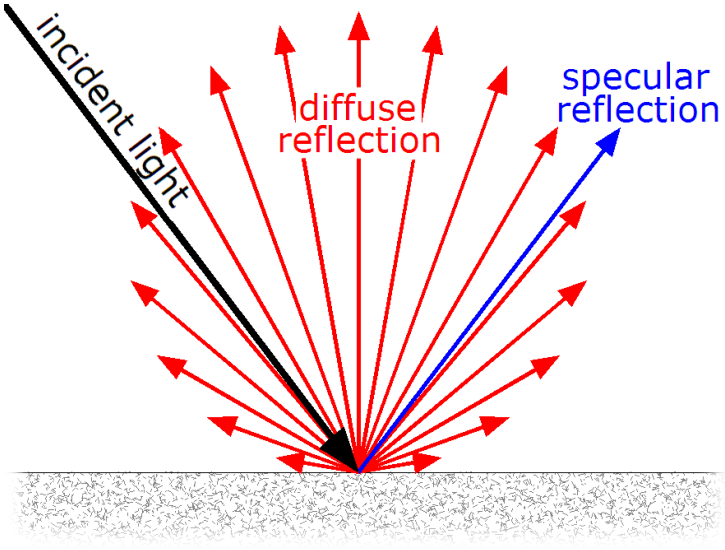

Figure 1

Figure 2-1

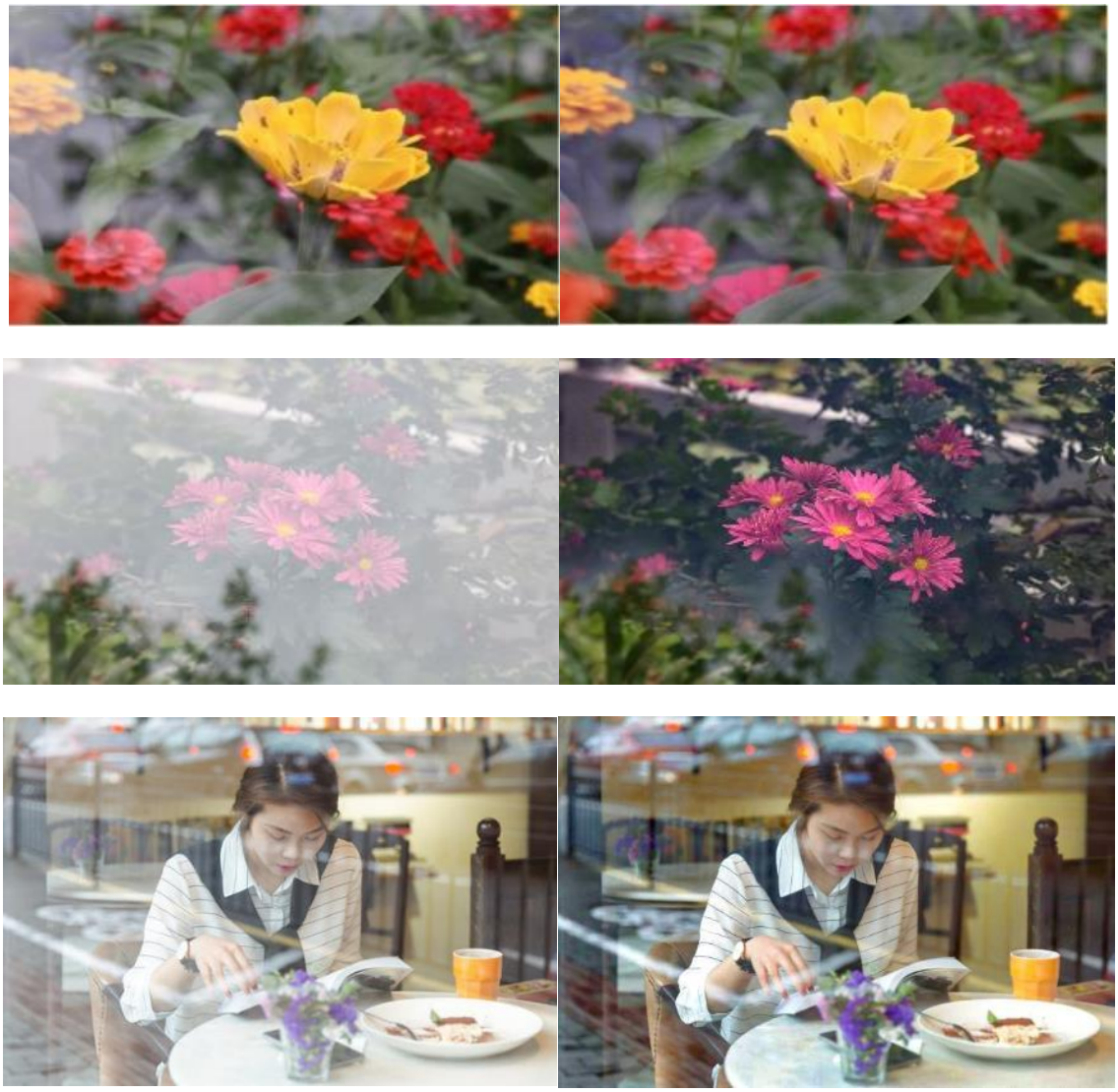

Figure 2-2: result of dark channel

COMPARE DCP ALONE WITH OTHER REFLECTION REMOVAL METHOD

First, we compare the dark channel prior alone with other non-learning method. We compare the results of dark channel with works of Yang [2] and Yu [3]. As we can see, the dark channel method outperforms Yang (fig 3) and Yu (fig 4) visibly.

Figure 3: from left to right: input, result of dark channel, result of Yang[2]

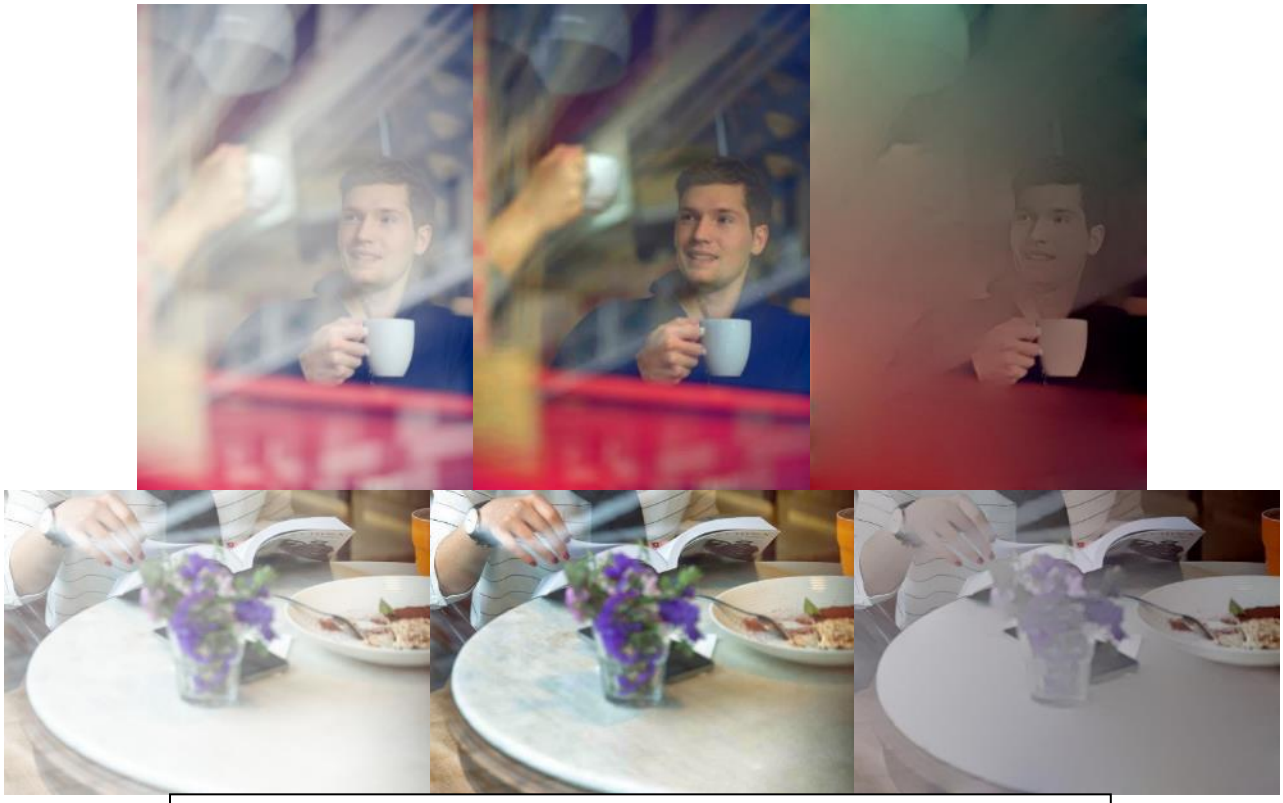

Figure 4: from left to right: input, result of dark channel, result of Yu[3]

Next, we compare the dark channel with other deep learning method. We choose 20 image with high level of diffusion reflection from Chao's nature dataset[4] and 20 image randomly from SIR dataset[5] and zhang's dataset[6], the results are shown below.

		zhang[6]	**BDN[7]**	**RmNet[8]**	**ERRNet[9]**	**Ours**	**input**
Diffusion（20）	PSNR	17.54	14.90	17.30	18.28	19.69	16.31
	SSIM	0.729	0.586	0.721	0.731	0.764	0.631
Others（20）	PSNR	20.98	21.55	20.27	23.50	23.02	22.98
	SSIM	0.832	0.843	0.792	0.868	0.829	0.828
Time on 512x512	6 core intel cpu	5.47	0.68	N/A	13.24	0.075	N/A

Table 1, PSNR , SSIM and execution time [10]of each algorithm.

Figure 5: PSNR , SSIM and execution time [10]of each algorithm. From left to right: input,zhang[6],BDN[7],RmNet[8],ERRNet[9],dark channel and ground truth.

We can observe that current reflection removal method tends to falsely remove the texture and content from input image when there is high level of defuse reflection is presented (line 1 and 3 of fig 5). when the strength of diffuse reflection is low (line 2, 4 and 5 in fig), dark channel method will keep texture and general structure of the inputs, therefore it will still get a decent result. In fact, Quantitative results of inputs image are surprisingly higher than many learning methods. Similar result are found on other researcher's paper such as kim[11] in table 2.

Dataset	Index	Methods									
		Input	CEILNet [7]	CEILNet FW	CEILNet FR	Zhang [36]	Zhang FW	Zhang FR	BDN [34]	Wen [32]	Ours
SIR Wild [28]	PSNR	25.89	20.89	19.23	22.51	21.15	21.34	23.18	22.02	21.26	25.55
	SSIM	0.903	0.826	0.819	0.880	0.851	0.865	0.890	0.835	0.835	0.905
Real 100	PSNR	21.53	19.24	17.82	20.35	18.66	18.88	20.44	19.46	19.07	21.59
	SSIM	0.797	0.733	0.706	0.764	0.750	0.753	0.773	0.753	0.728	0.789
Rendered Testset	PSNR	23.27	19.31	20.23	23.46	22.21	21.83	24.43	21.66	21.79	27.90
	SSIM	0.846	0.745	0.777	0.829	0.829	0.828	0.854	0.819	0.804	0.894

Table 2: Quantitative results obtained by kim[11]

Finally, we test the dark channel on some real-life image without ground truth. In figure 6, dark channel is the only one that recovers the black color of the female's sweater in the red and green boxes. None of 8 learning methods from 2018 to 2020 manage to recover both of them. In figure 7, the dark channel also performed better in remove the diffuse reflection on the man and woman's faces without generating scratch on their hair and face or overly removing the brightness.

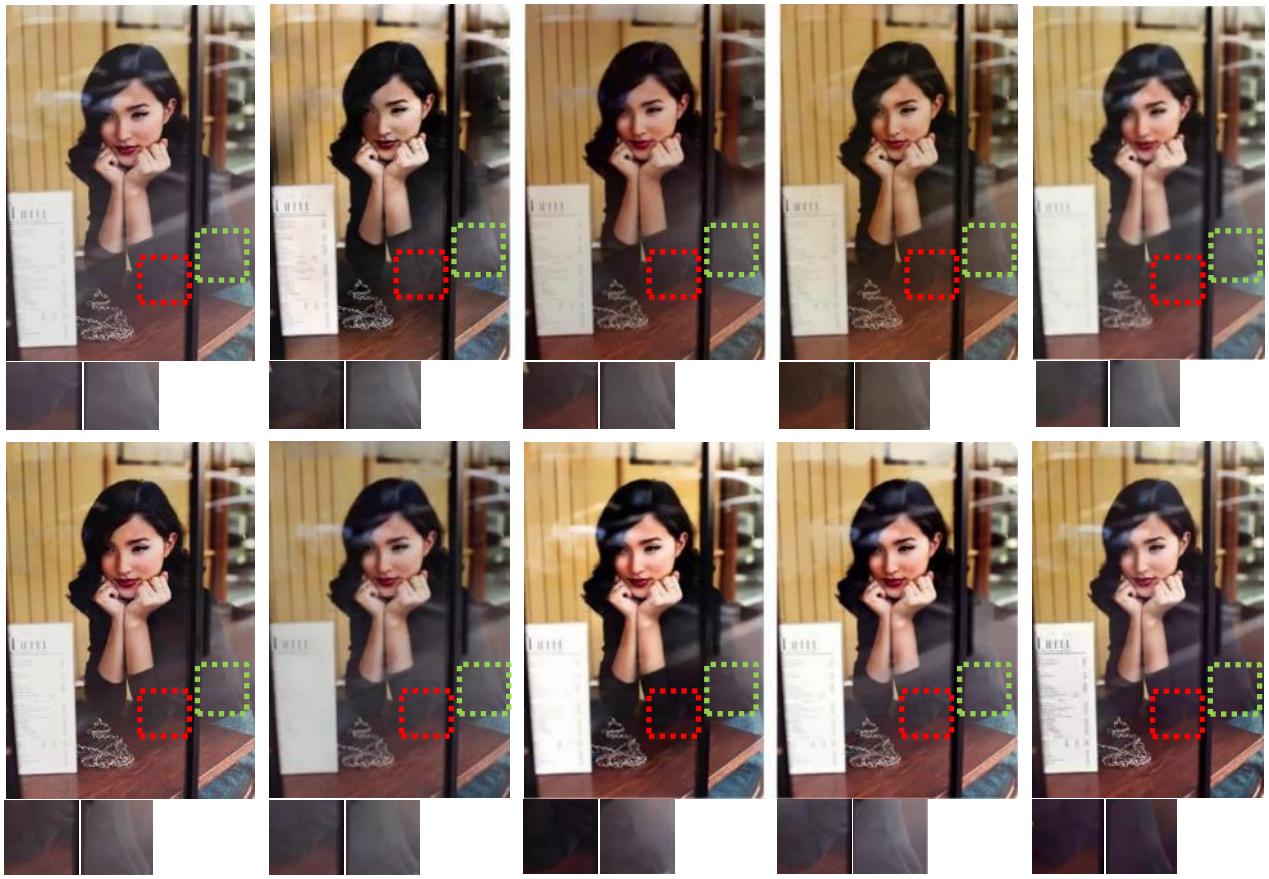

Figure 6: results on real life image. Top line from left to right: input, Fan[12], wan[13], zhang[6] and Li[14]. Bottom line from left to right:, Yu[19] wan[15], yang[16], Daniel [17],and dark channel.

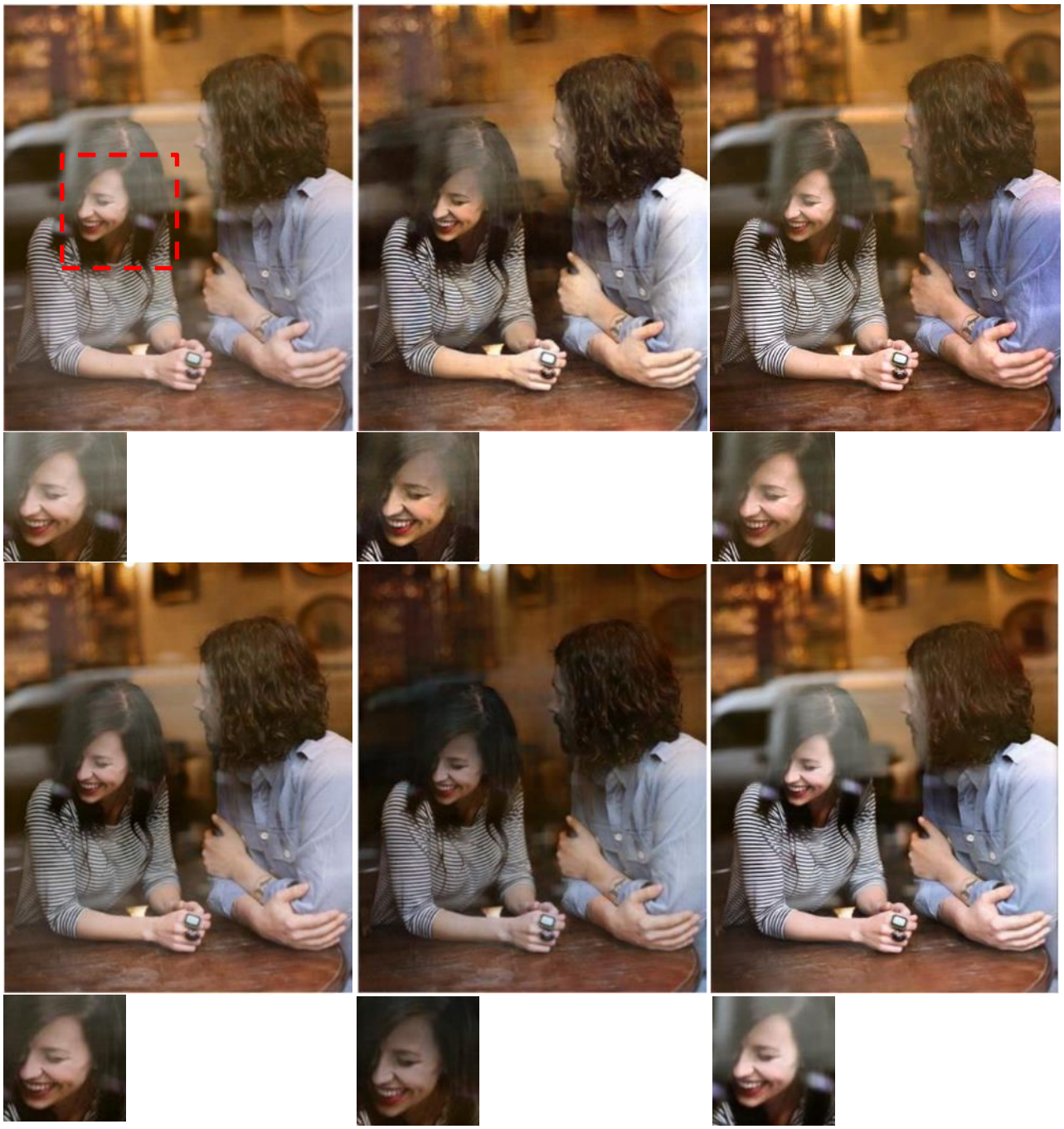

Figure 7: results on real life image. Top line from left to right: input, Fan[12] and dark channel. Bottom line from left to right: Wei [18], zhang[6], and yang[7].

COMBINE DCP WITH CURRENT LEARNING METHOD

From previous section we can see that DCP can remove some reflection which current learning method can't handle. If we use both of them on one picture, then we can get a better result than using either of them alone. In fig 8 below we can see some results of combine the dark channel and kim[11]. In first row neither algorithm can remove the reflection in blue and green box at the same time, but when we combine them together, we can remove the reflection in both of them. On the second and the third rows, neither algorithm can remove the reflection in the box area indicated on picture. However, with both of them applied, we will have a good reflection reduction in those area. In figure 9 we also shows the combination result with Li[14] and Yu[19]. See supplemental material at the end of page for more example.

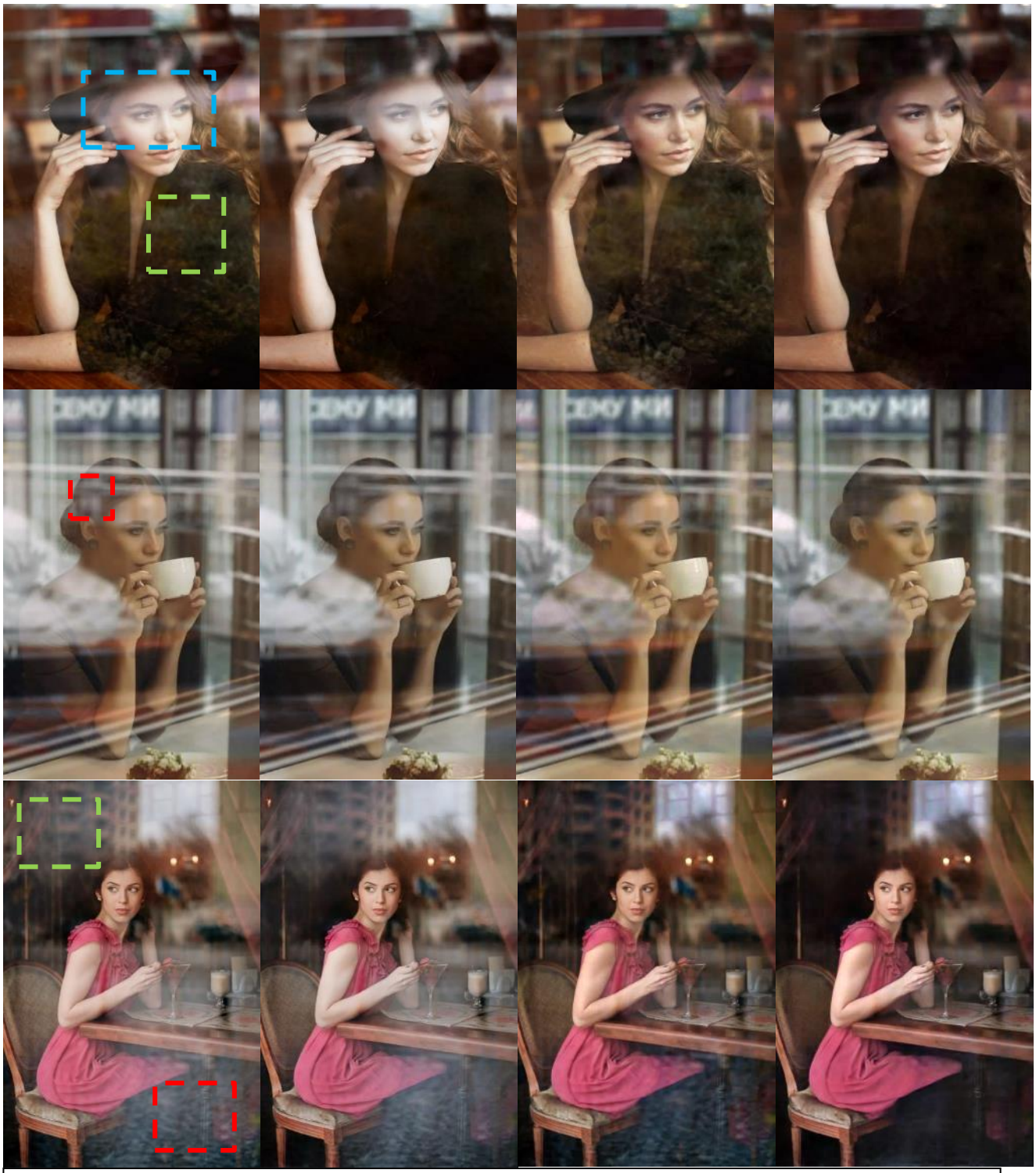

Figure 8: from left to right: input, kim[11] , dark channel and dark channel + kim

Figure 9: results on real life image. Top line from left to right: input, kim[11] , dark channel and dark channel + kim. Bottom line from left to right: Li[4], dark channel + Li, Yu[19], dark channel +Yu

SHOTCOMING OF DARK CHANNEL PRIOR

There are 2 major short coming for dark channel prior. First it will change the color tune of input image greatly if the reflector has color like zhang[6]. This can be fixed by adjust the color tune of image. Second, removing the diffusion reflection may generate noises on some situation, a denoise post process may needed to handle it. Figure 10 show a example for each problem.

Figure 10: examples of change in color tune (top) and noise (bottom)

CONCLUSIONS

It is just a small trick but it indeed can improve the quality of reflection removal. There are so many code examples for dark channel on web, you can easily find one and try this out. If you still have any question, feel free to ask me.

REFERENCES

Note: references are **required**. This section is included in the five-page limit.

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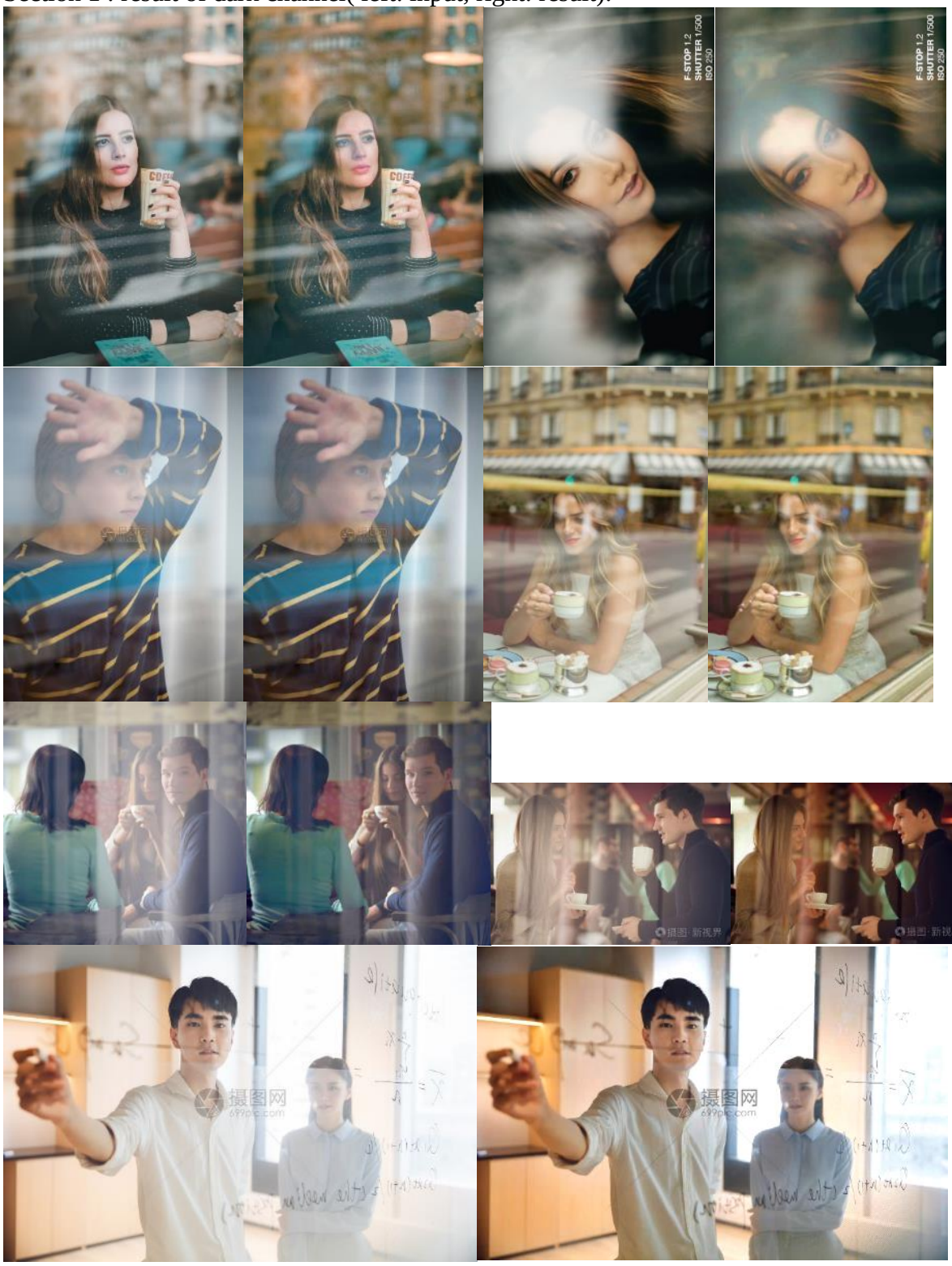
Supplement material

Section 1 : result of dark channel(left: input, right: result):












Section 2 : combine with kim[11] (from left: input, kim, dark channel ,dark channel +kim)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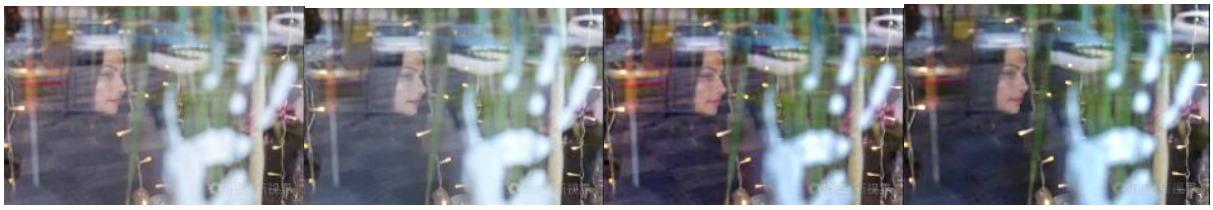

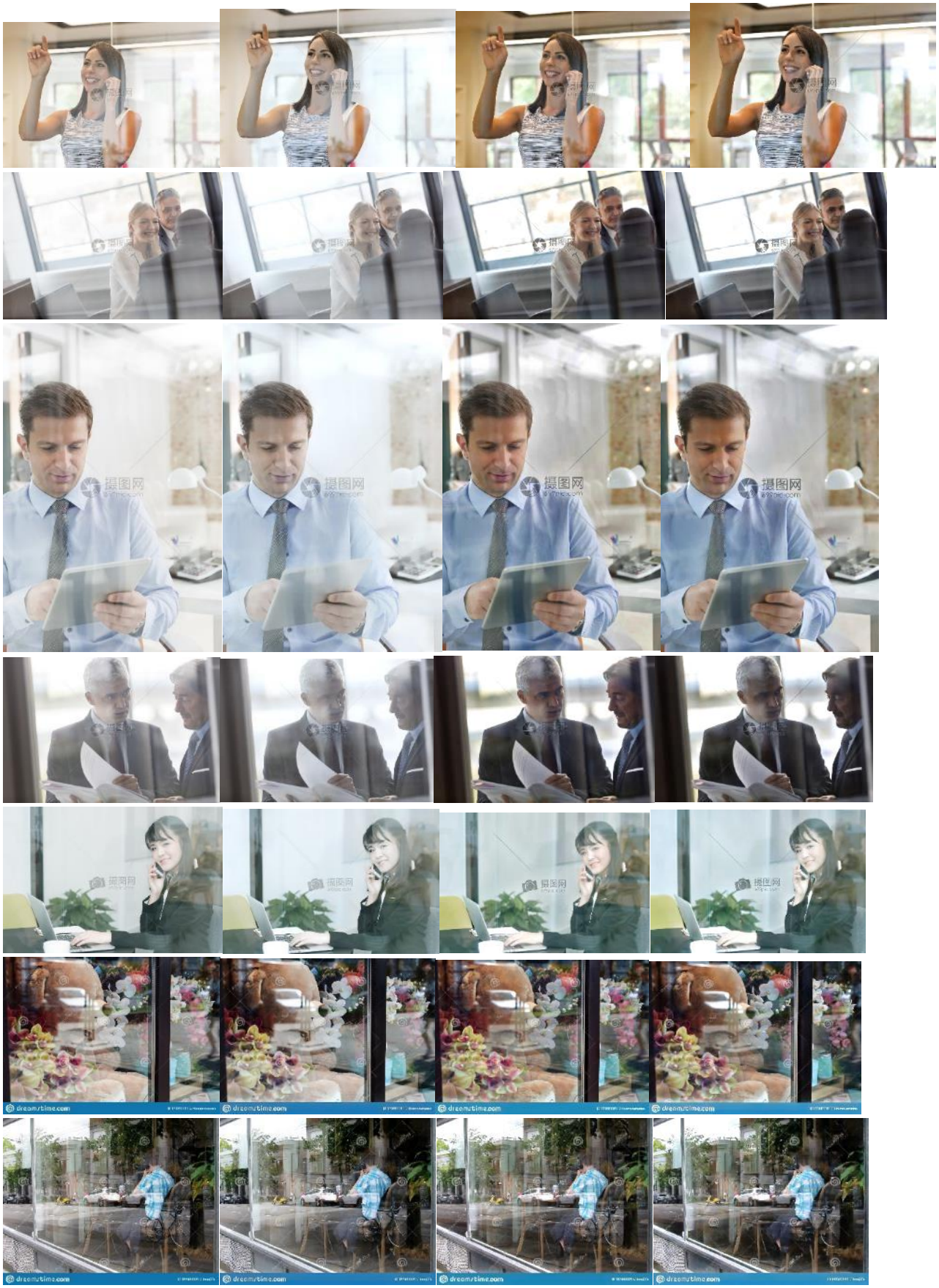


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