Distort-and-Recover: Color Enhancement using Deep Reinforcement Learning Supplementary Material

1. Artifact-free

In photo retouching, it is important to prevent any production of artifacts regardless of the input images' resolutions. Our approach produces a sequence of global color adjustment operations, so there is no unreal artifacts produced by nature, and there is no dependency on the input resolution. On the other hand, previous approaches such as Yan *et al*. [2], or our baseline Pix2Pix [1] are pixel-wise dense predictions, and have the risk of artifacts in the produced images as shown in Fig. 1. Encoder-decoder approach such as [1] may not effectively handle varying input image sizes. Pixel-wise prediction approach such as [2] may suffer from the instability of pixel-wise pre-processing such as semantic segmentation. Also, wrong semantic segmentation results also may lead to worse retouched results.

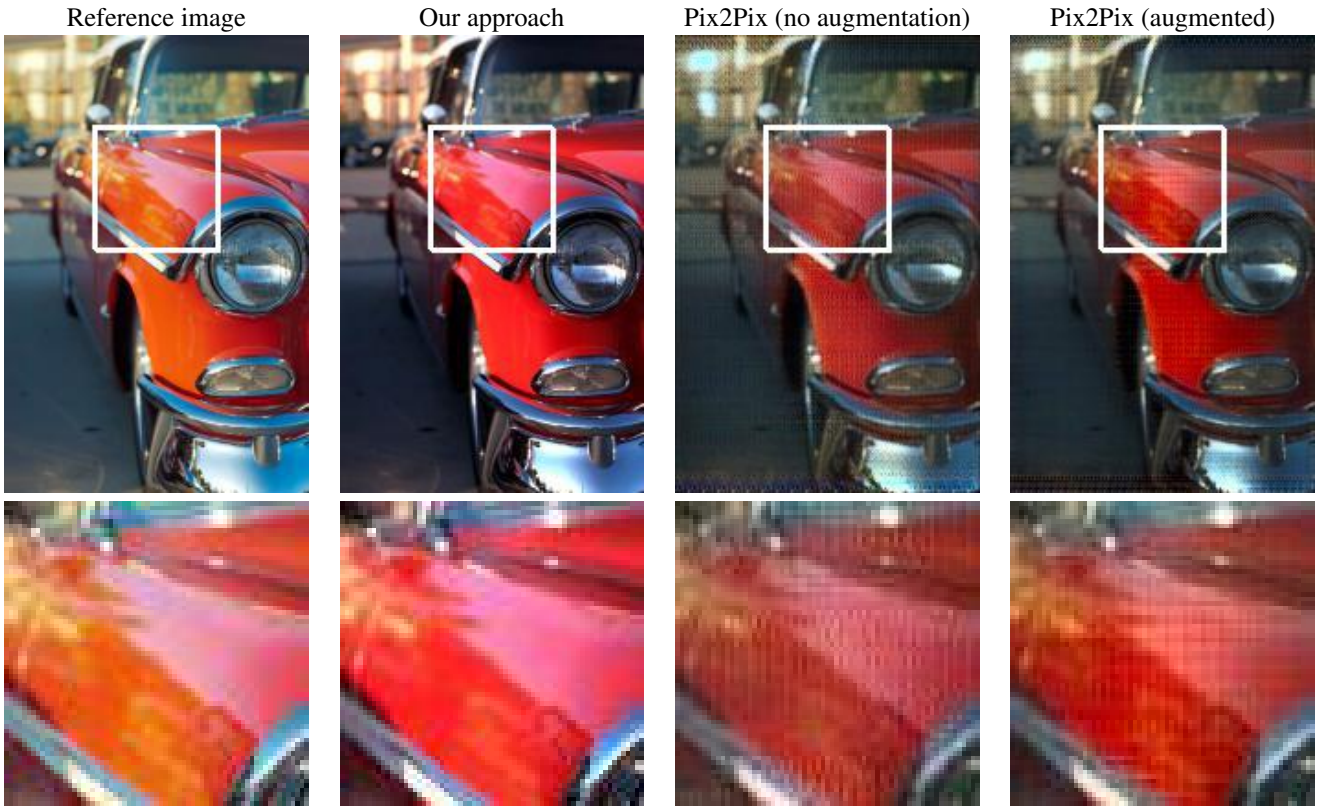


Figure 1. Examples from test results in distort-and-recover training scheme. The checkerboard artifacts are found in Pix2Pix baseline approaches, while our approach has no artifacts. The images' resolution is adjusted according to the supplementary material size limitation.

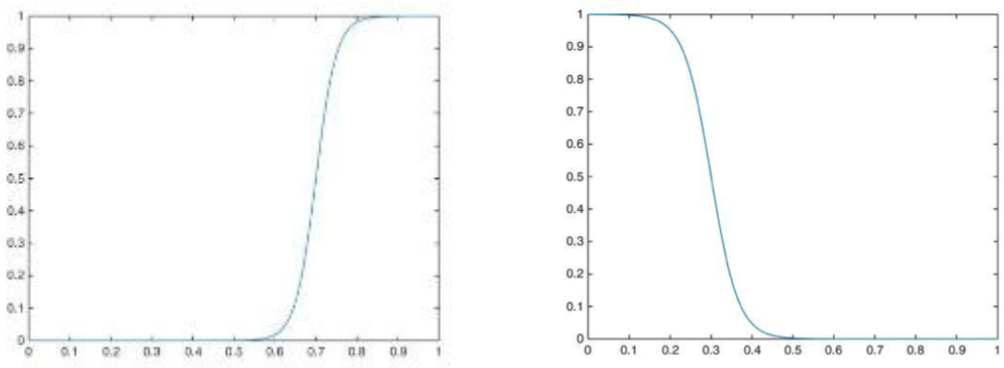


Figure 2. Pixel selection functions' curves to select pixels with high values or low values.

2. Distortion operations

In this section, we will explain the distortion operations used for the proposed '*distort-and-recover*' training scheme. For a fair comparison between our DRL method and other approaches, we have used distortion operations different from the ones used by our DRL retouching agent, except that some basic color adjustment operations (brightness, color saturation, contrast) are shared.

Other than the shared basic color adjustment operations, non-linear operations are added in the distortion set. There are 2 steps in non-linear operations: 1) pixel selection and 2) adjustment operation.

2.1. Pixel selection

A weight map over the image is computed for pixel selection. In the weight map, target pixel values will be near 1, and other pixels are near 0. Pixels are selected after applying the target channel's pixels to the function below:

$$\mathcal{W}_{hl\_threshold,steepness}(x) = (tanh(x - hl\_threshold) * \text{steepness} + 1)/2 \tag{1}$$

$$\mathcal{W}_{shadow\_threshold,steepness}(x) = 1 - (tanh(x - shadow\_threshold) * \text{steepness} + 1)/2 \tag{2}$$

Eq 1 is for selecting pixels with high values, for example, highlight region pixels; Eq 2 is for selecting low values, for example, shadow regions. Highlight pixels are selected by applying Eq 1 in L channel, and shadow pixels are selected by applying Eq 2 in L channel. In addition, C/M/Y/R/G/B pixels are selected in respective color channel with Eq 1. The pixel selection functions are modified from *tanh* function to smoothly select the target pixels. **x** is the target channel's pixel value and **hl_thresold/shadow_threshold, steepness** are the parameters to choose the threshold and smoothness of the selection curve.

Curves for the selection functions are shown in Figure 2, and an example of selecting the highlight region (apply Eq 1 in L-channel) is shown in Figure 3. After the pixels are selected with the weight map, operations will be applied to increase or decrease the target pixels' values.

2.2. Non-linear operations

In distortion operations, we select different channels and apply changes upon the target pixels. For example, we can select highlight pixels with high values in L channel to change the contrast or brightness; we can select pixels with high cyan values to change the cyan intensity. The full list of operations are shown in Table 1. There are linear operations (brightness, color saturation, contrast) included in the distortion operation set. To select high values as stated in the table, Eq 1 is used; to select low values as stated in the table, Eq 2 is used. There are in total 26 types of operations in the distortion set.

Random operations are selected from 26 linear/non-linear operations, and applied to the reference image in random sequence. To prefent opposite operations to be chosen and nullify each other, only one in each pair can be chosen. The $\mathcal{L}^2$ distance between distorted images and correspoding reference images are kept between 10 and 20 in CIE Lab color space. Examples of distorted images are shown in Figure 4.

Raw image Weight map

Figure 3. Pixel selection example for highlight region pixels (high L channel values).

#	Action description (linear)	#	Action description (non-linear)
1	↓ brightness (×0.6∼0.8)	7	select highlight pixels (high L channel), ↓ brightness (×0.6∼0.8)
2	↑ brightness (×1.2∼1.4)	8	select highlight pixels (high L channel), ↑ brightness (×1.2∼1.4)
3	↓ color saturation (×0.6∼0.8)	9	select shadow pixels (low L channel), ↓ brightness (×0.6∼0.8)
4	↑ color saturation (×1.2∼1.4)	10	select shadow pixels (low L channel), ↑ brightness (×1.2∼1.4)
5	↓ contrast (×0.6∼0.8)	11	select highlight pixels (high L channel), ↓ color saturation (×1.2∼1.4)
6	↑ contrast (×1.2∼1.4)	12	select highlight pixels (high L channel), ↑ color saturation (×1.2∼1.4)
		13	select shadow pixels (low L channel), ↓ color saturation (×0.6∼0.8)
		14	select shadow pixels (low L channel), ↑ color saturation (×1.2∼1.4)
		15	select C pixels (high Cyan channel), ↓ Cyan (×0.6∼0.8)
		16	select C pixels (high Cyan channel), ↑ Cyan (×1.2∼1.4)
		17	select M pixels (high Magenta channel), ↓ Magenta (×0.6∼0.8)
		18	select M pixels (high Magenta channel), ↑ Magenta (×1.2∼1.4)
		19	select Y pixels (high Yellow channel), ↓ Yellow (×0.6∼0.8)
		20	select Y pixels (high Yellow channel), ↑ Yellow (×1.2∼1.4)
		21	select R pixels (high Red channel), ↓ Red (×0.6∼0.8)
		22	select R pixels (high Red channel), ↑ Red (×1.2∼1.4)
		23	select G pixels (high Green channel), ↓ Green (×0.6∼0.8)
		24	select G pixels (high Green channel), ↑ Green (×1.2∼1.4)
		25	select B pixels (high Blue channel), ↓ Blue (×0.6∼0.8)
		26	select B pixels (high Blue channel), ↑ Blue (×1.2∼1.4)

Table 1. Non-linear operations. The adjustment rate is randomly chosen in the specified range.

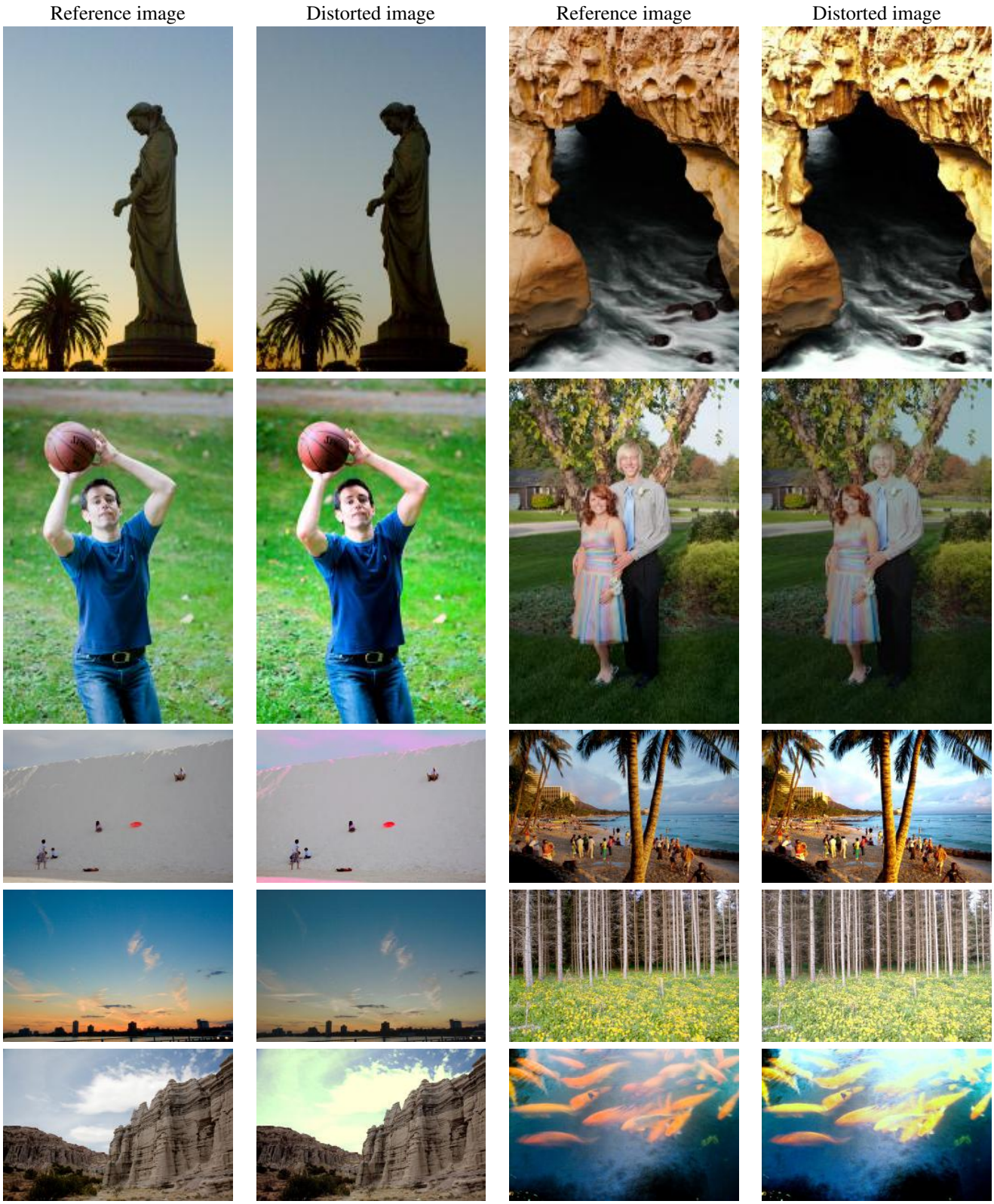


Figure 4. Example distorted images.

3. Learn a style filter

In Sec. 6.4, our agent is trained to learn a specific style ('Nashville' filter) with distort-and-recover scheme. Examples are shown below to qualitatively demonstrate that our agent is capable of learning specific styles.

Figure 5. Qualitative comparison of our approach trained with different style datasets. The "Nash" dataset is created by stylizing Expert C images with "Nashville" filter. The *distort-and-recover* training scheme is used in both cases.

4. Experiment results

In the following subsections, the full test set for each experiment is listed.

- **Section 4.1. User study images for distort-and-recover training scheme with Shutterstock 150K reference images.**

  This is the 50 image sets used for the user study. The 50 images are randomly selected out of MIT-Adobe FiveK dataset. In the user study, images are shown to respondents in a random order for each set. Pix2Pix and ours are trained under the *distort and recover* training scheme with Shutterstock 150K images. The statistics of raw scores and normalized scores are also listed.

- **Section 4.2. Experiment result using input-retouched image pairs from MIT5K expert C. (with intermediate action sequences)**

  We demonstrate intermediate action sequences chosen by our agent in the experiment using input-retouched image pairs.

- **Section 4.3. Experiment result using *distort-and-recover* scheme with Shutterstock 150K. (with intermediate action sequences)**

  We demonstrate intermediate action sequences chosen by our agent in the experiment using *distort-and-recover* scheme with Shutterstock 150K.

- **Section 4.4. Experiment result using input-retouched image pairs from MIT5K expert C. (compared with Pix2Pix baseline)**

  This is the full 250 test images and the enhancement results for the approaches. Results from our approach and the baseline Pix2Pix is shown because the entire test results for other approaches are not available.

- **Section 4.5. Experiment result using *distort-and-recover* training scheme on Shutterstock 150K images. (compared with Pix2Pix baseline)**

  This is the full 250 test images and the enhancement results for our method and Pix2Pix in augmented cases. Results from our approach and the baseline Pix2Pix is shown because the entire test results for other approaches are not available.

- **Section 4.6. Experiment result using *distort-and-recover* training scheme on Nashville-filtered reference images.**

  This is the full 250 test images and the enhancement results for our method. There are 2 different sets of images used here. 1) The retouched images from expert C in MIT-Adobe FiveK dataset, and 2) Nashville-filtered retouched images from expert C. In this experiment, we can qualitatively see that different styles can be learned using our method.

4.1. User study images for distort-and-recover training scheme with Shutterstock 150K reference images.

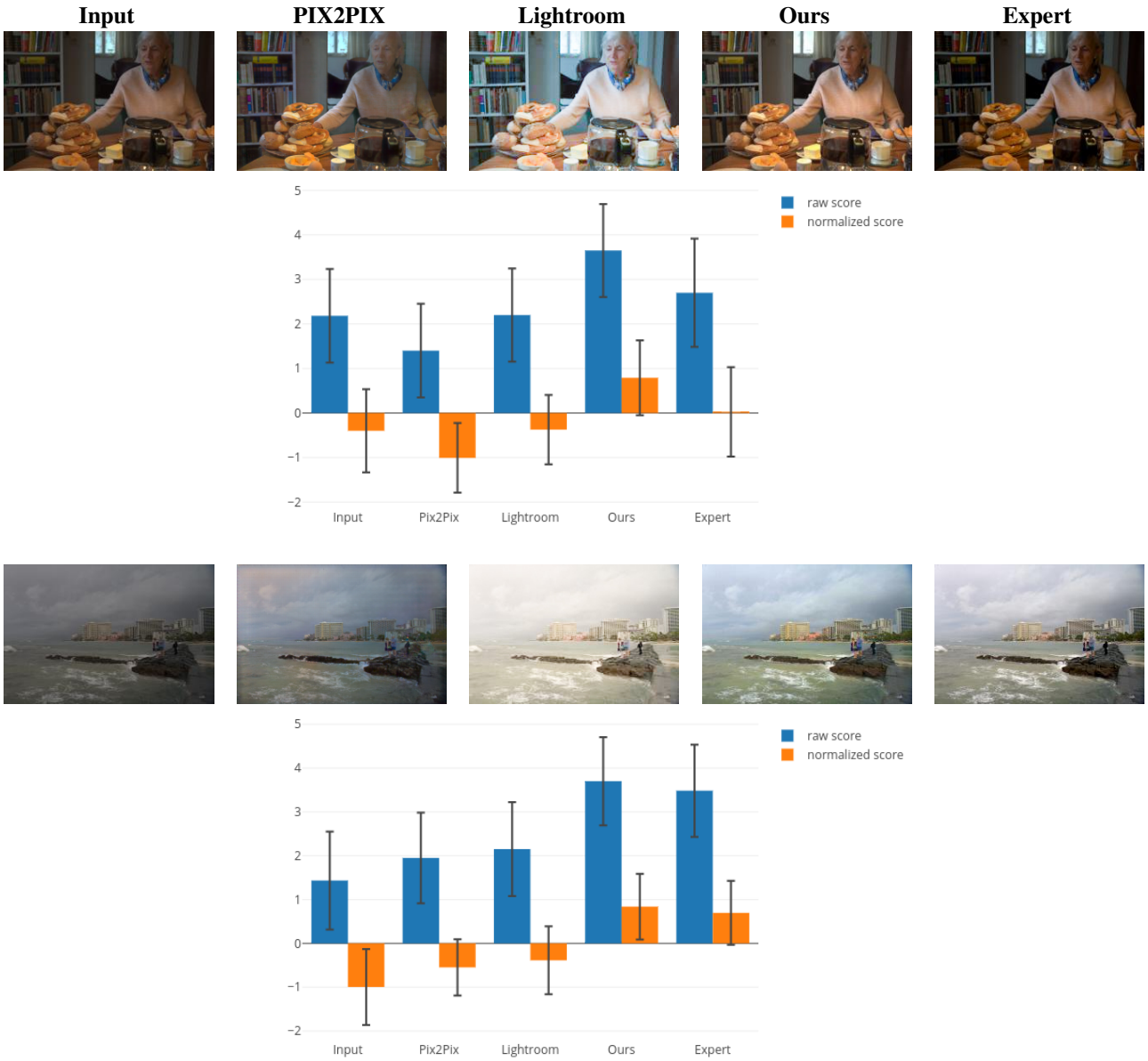


Table 2. [1 / 25] Images used in the user study.

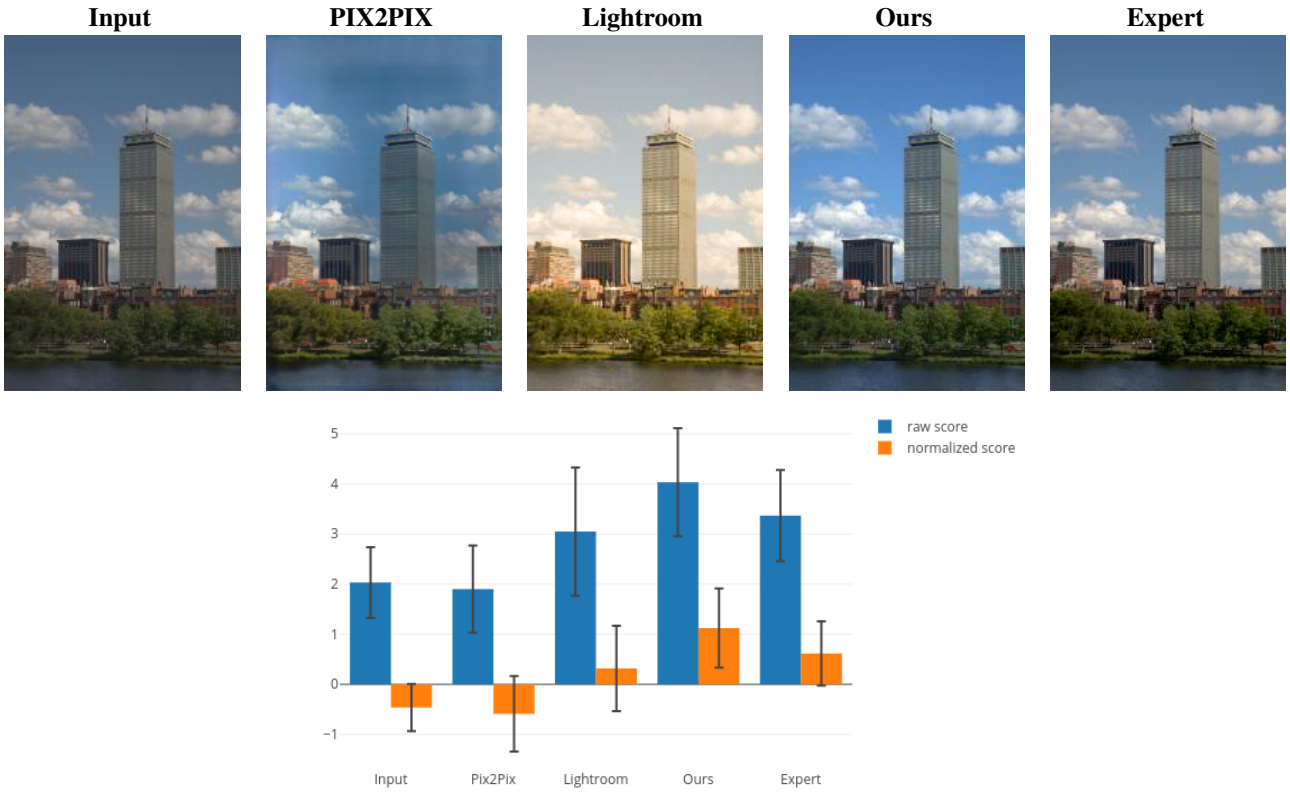


Table 3. [2 / 25] Images used in the user study.

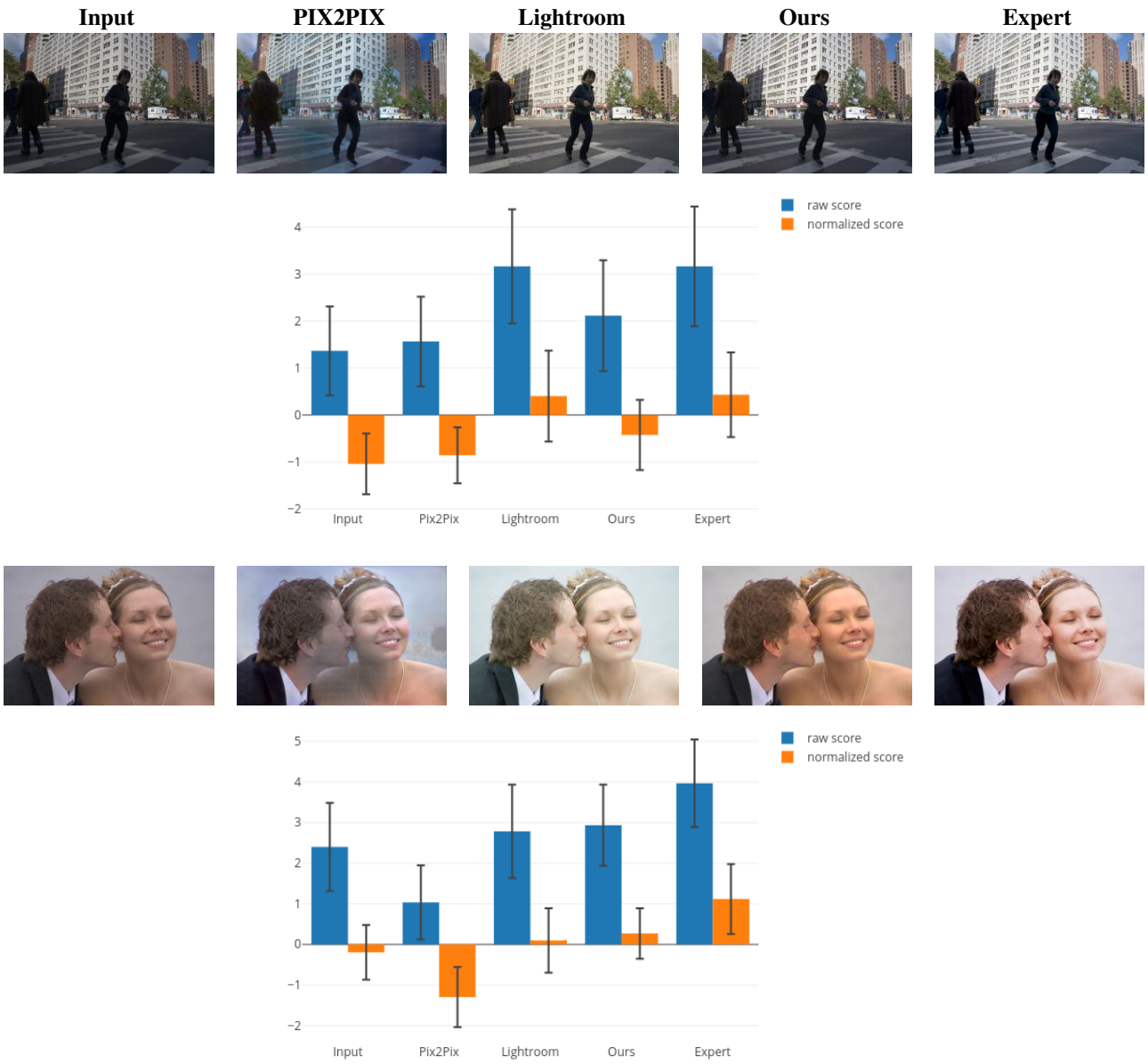


Table 4. [3 / 25] Images used in the user study.

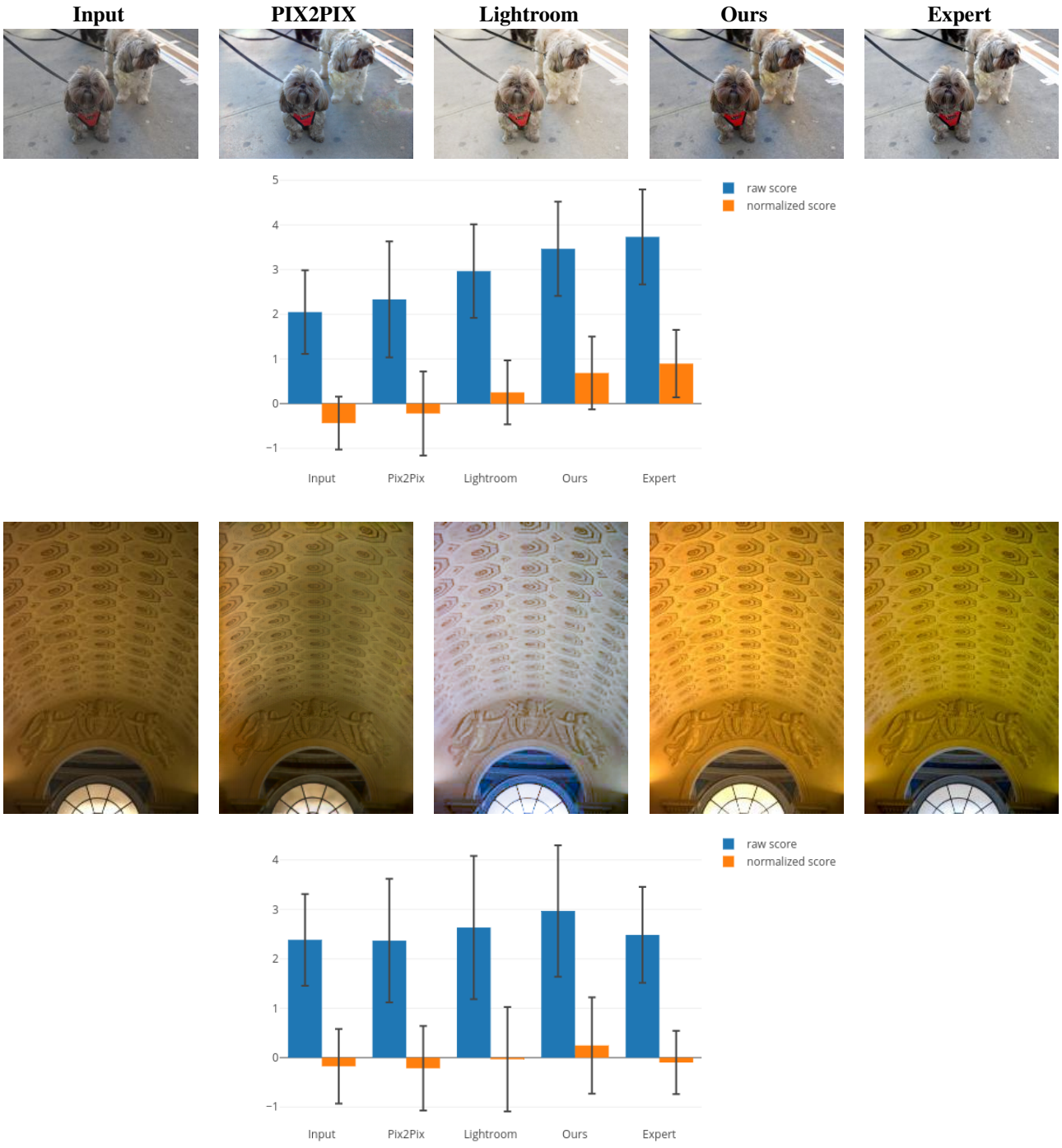
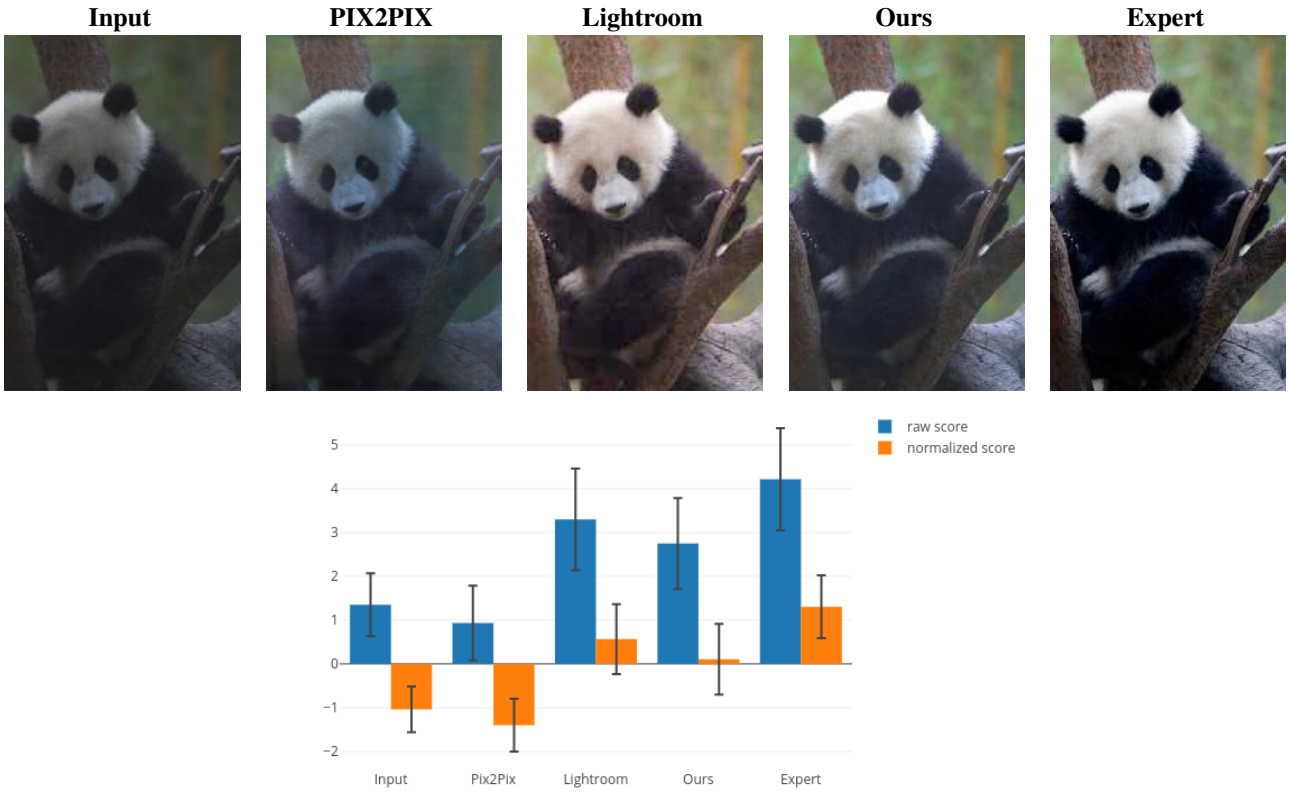


Table 5. [4 / 25] Images used in the user study.



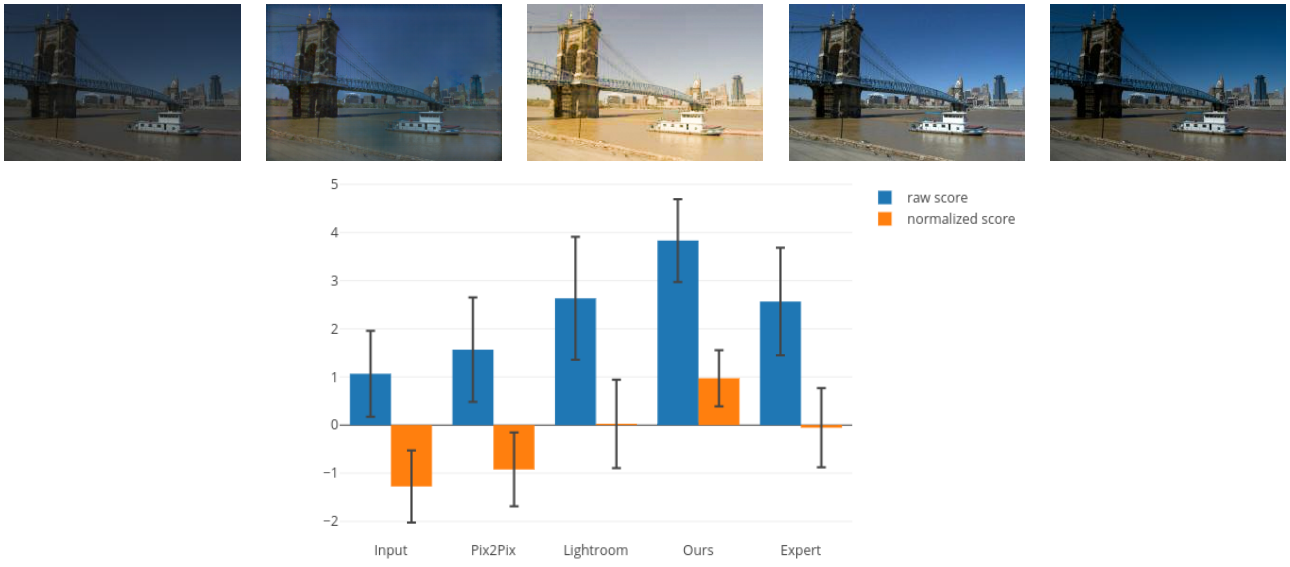


Table 6. [5 / 25] Images used in the user study.

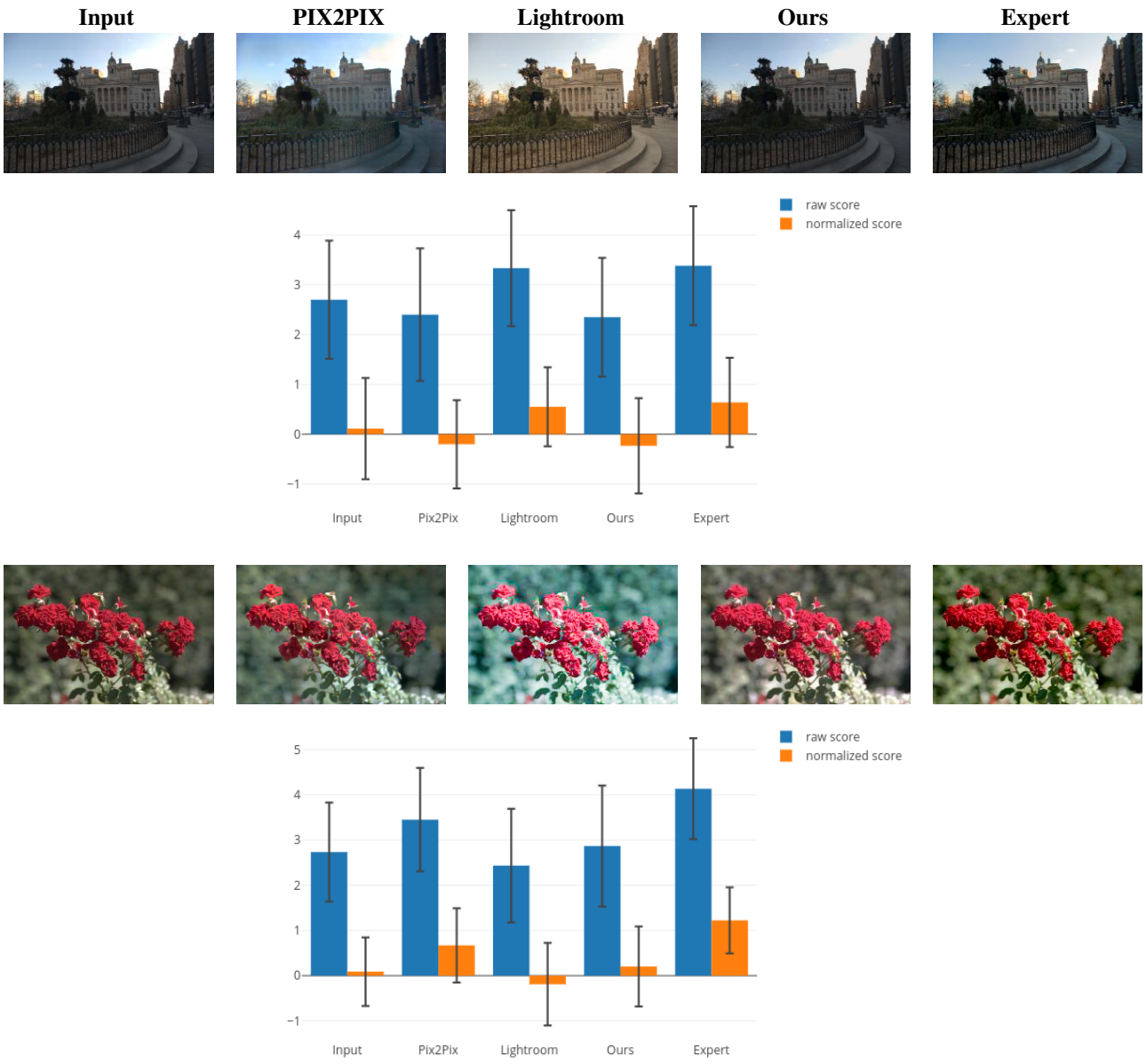


Table 7. [6 / 25] Images used in the user study.

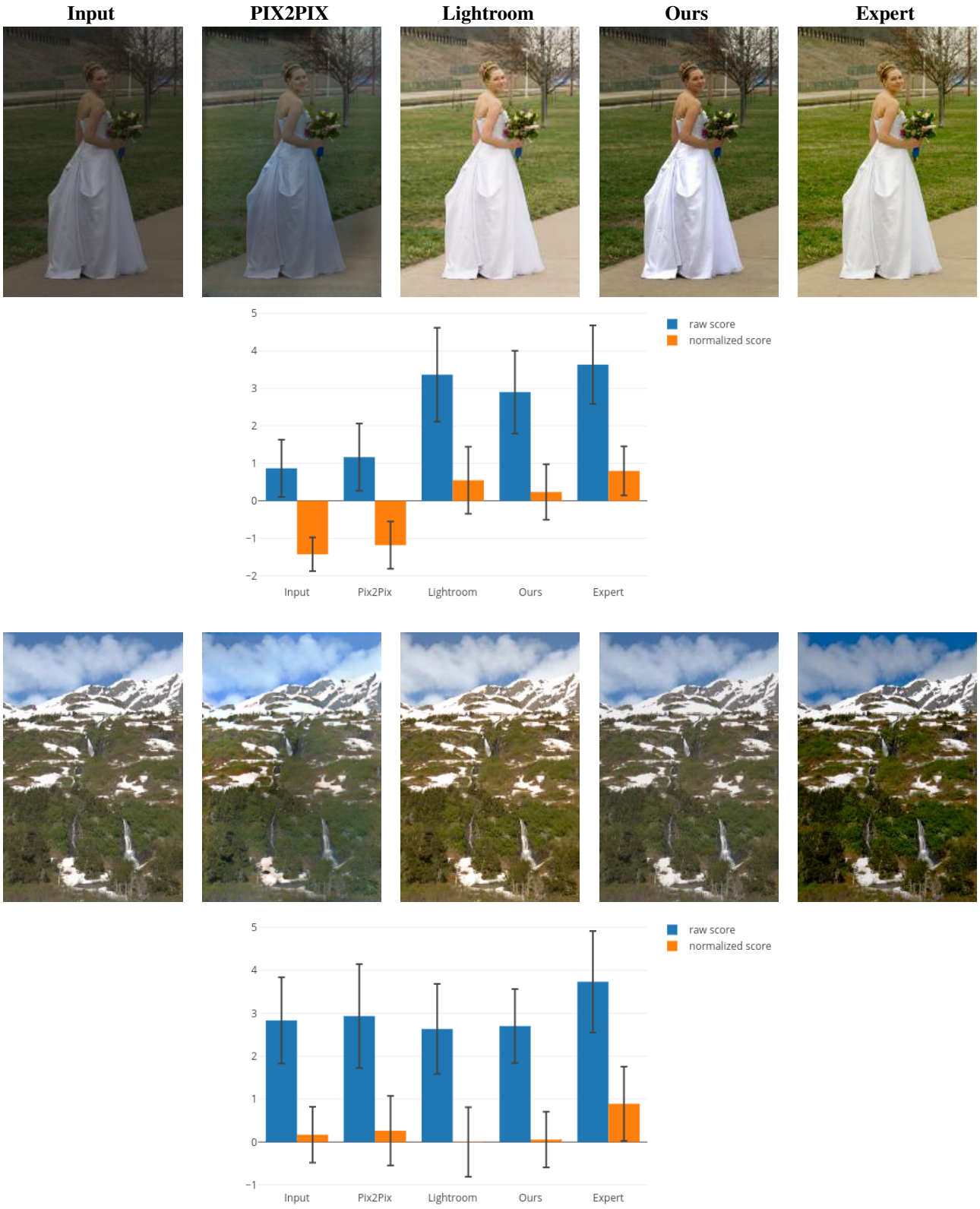


Table 8. [7 / 25] Images used in the user study.

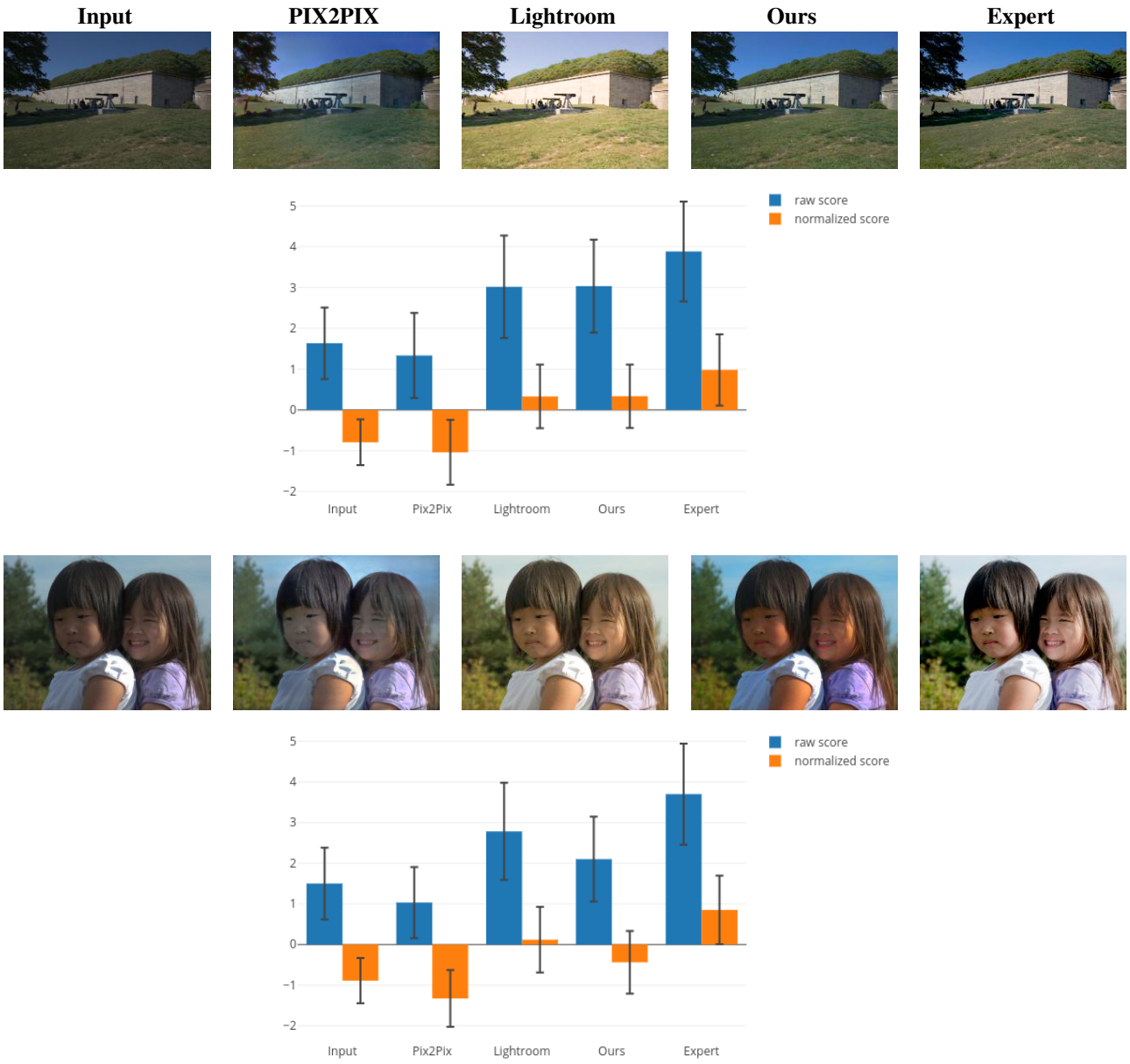


Table 9. [8 / 25] Images used in the user study.

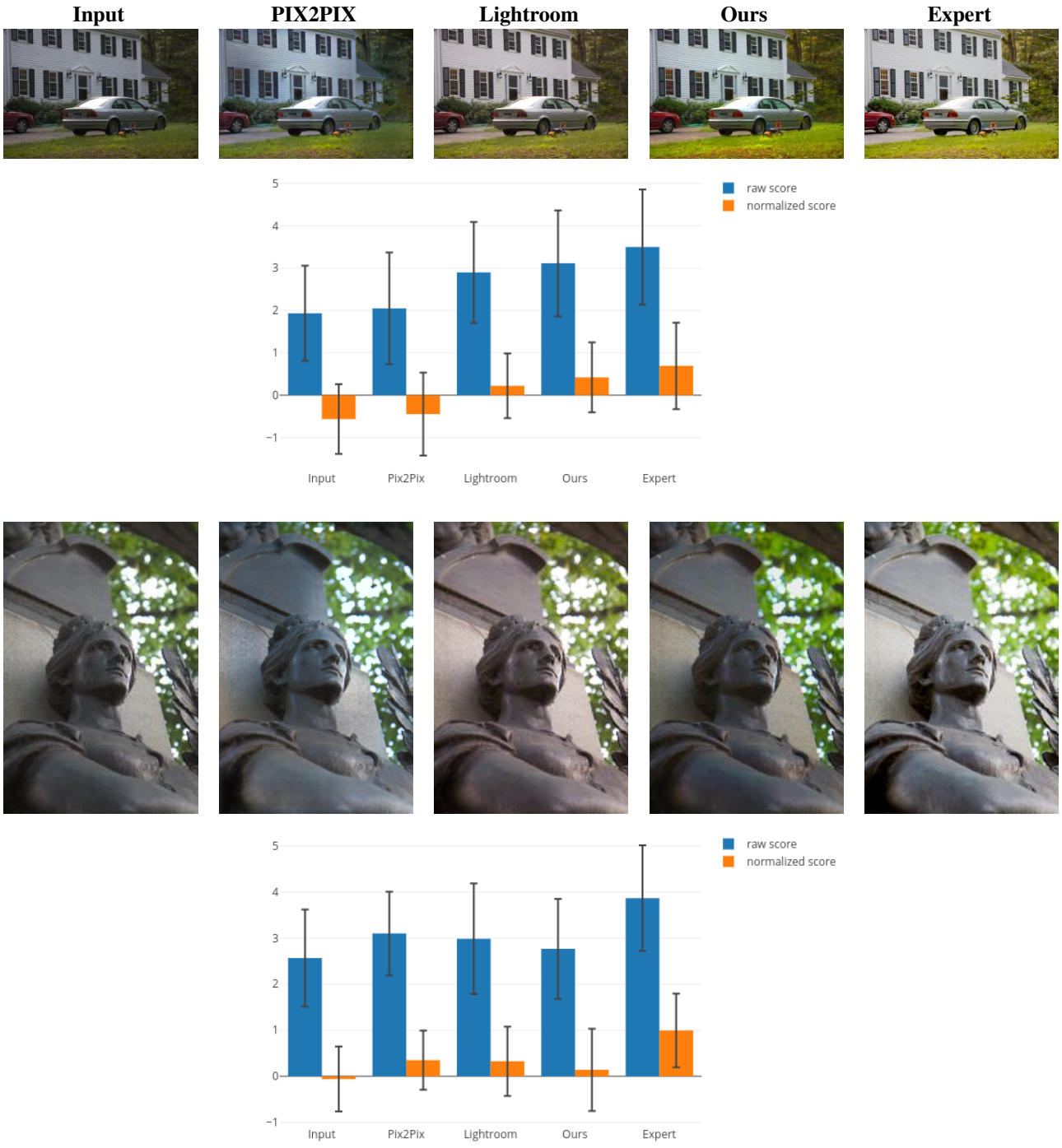


Table 10. [9 / 25] Images used in the user study.

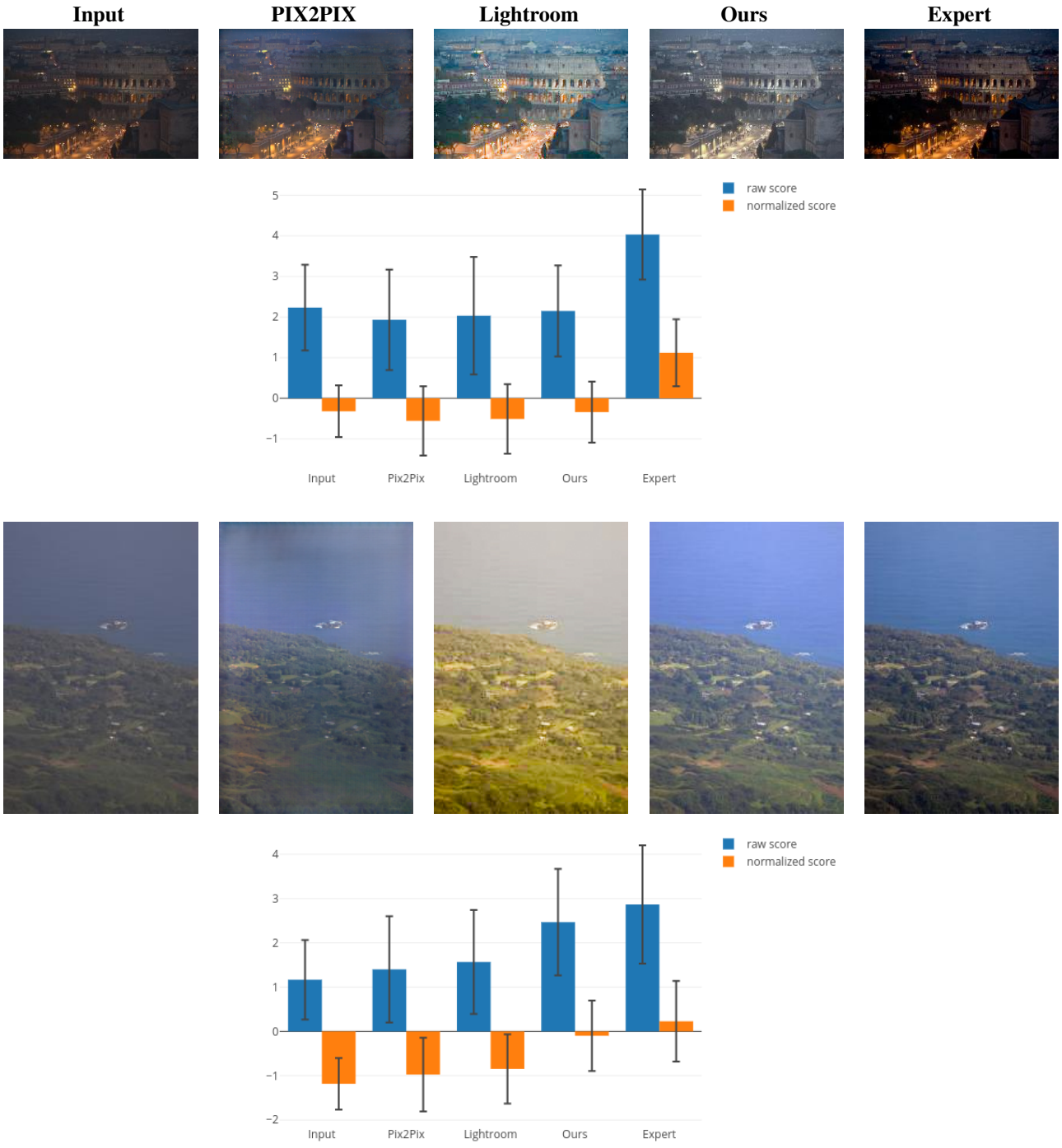


Table 11. [10 / 25] Images used in the user study.

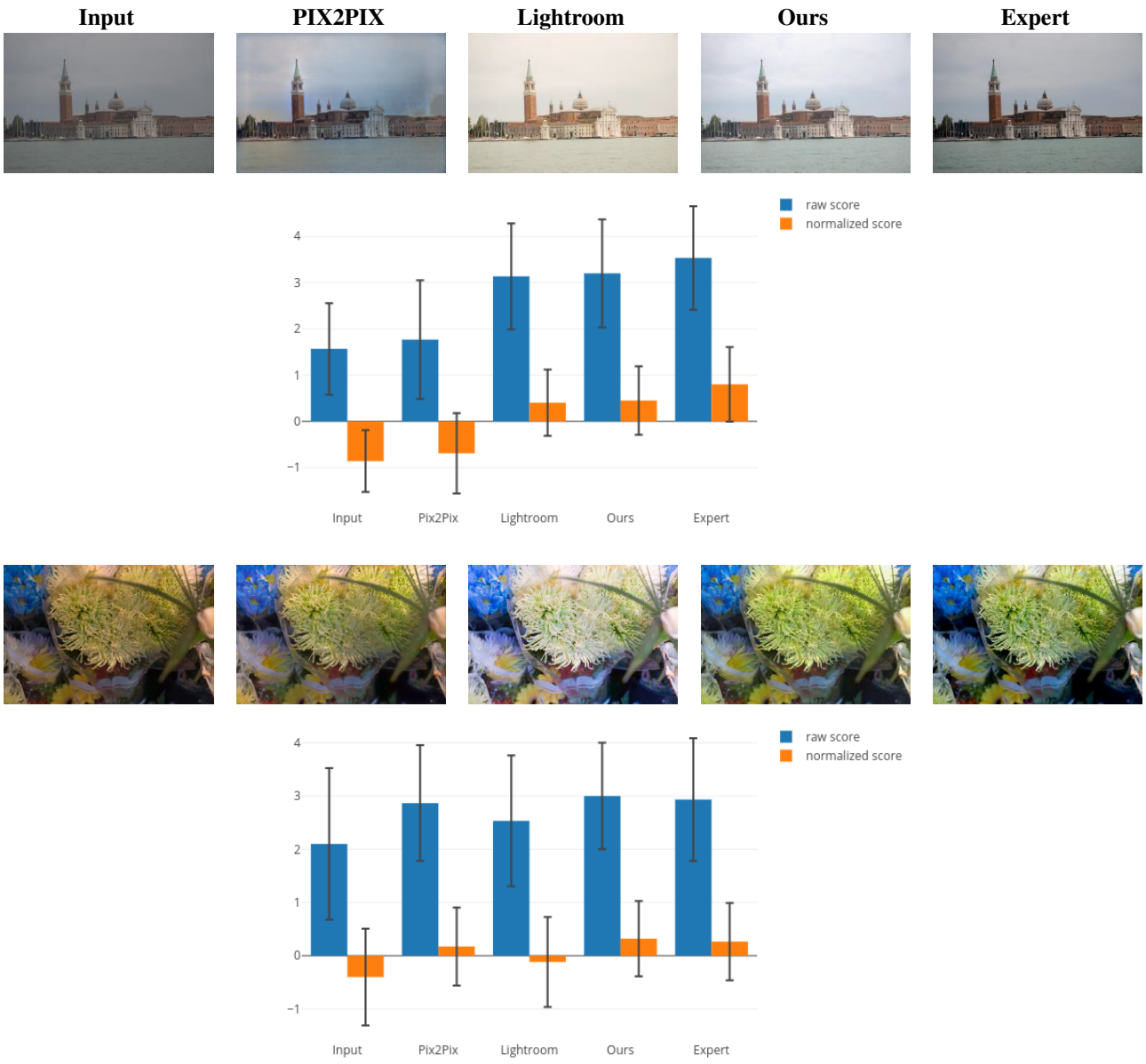


Table 12. [11 / 25] Images used in the user study.

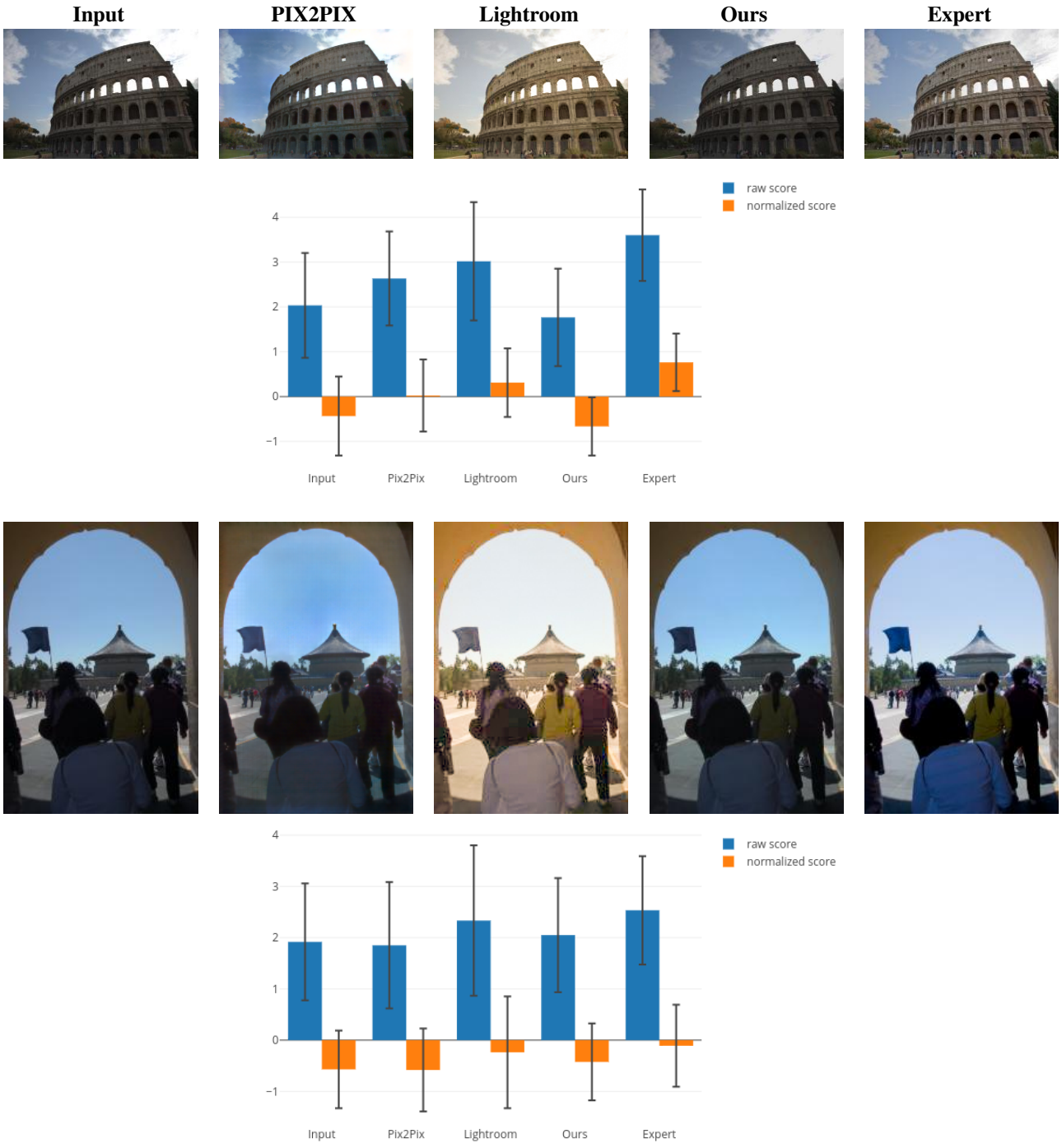


Table 13. [12 / 25] Images used in the user study.

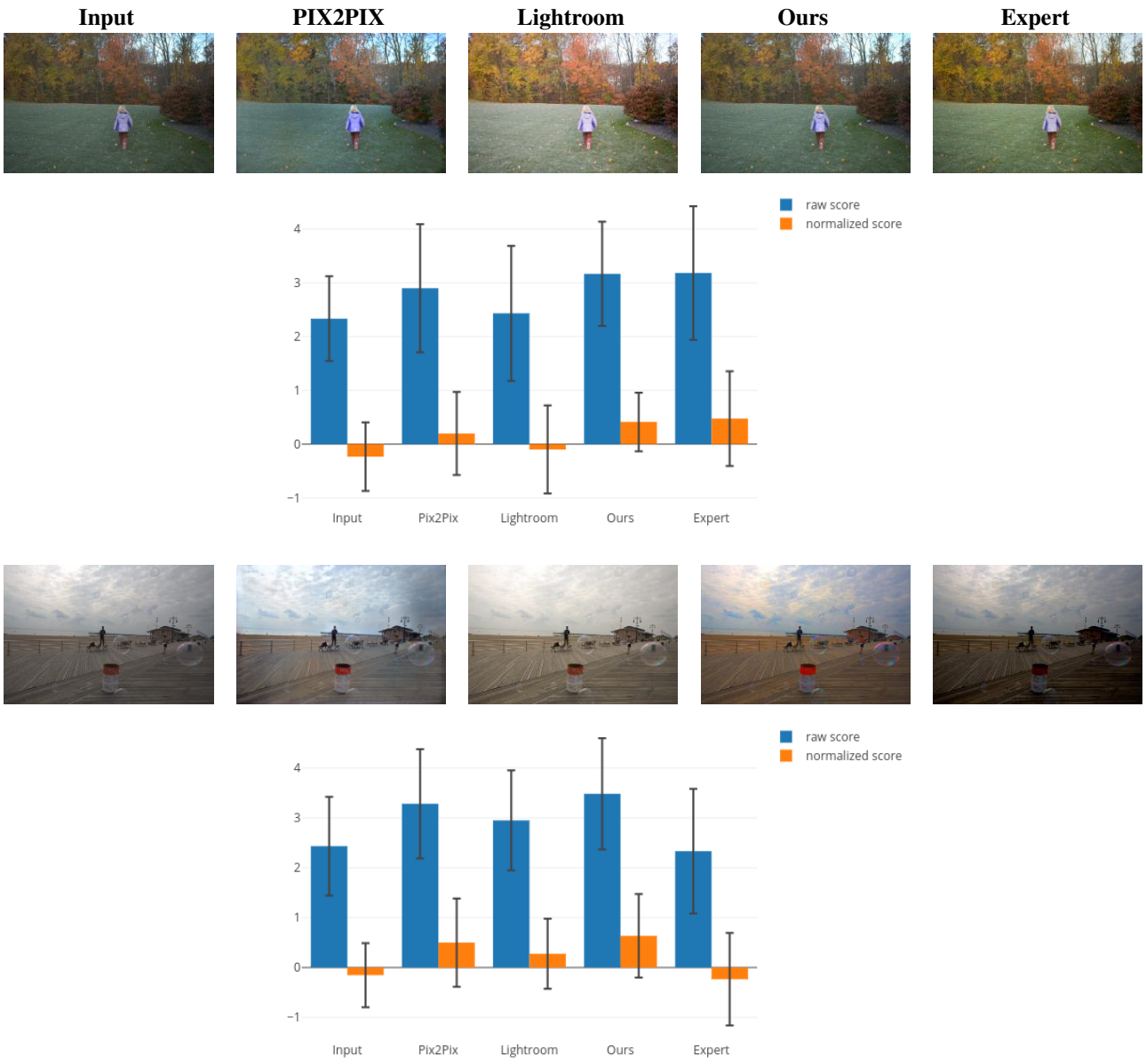


Table 14. [13 / 25] Images used in the user study.

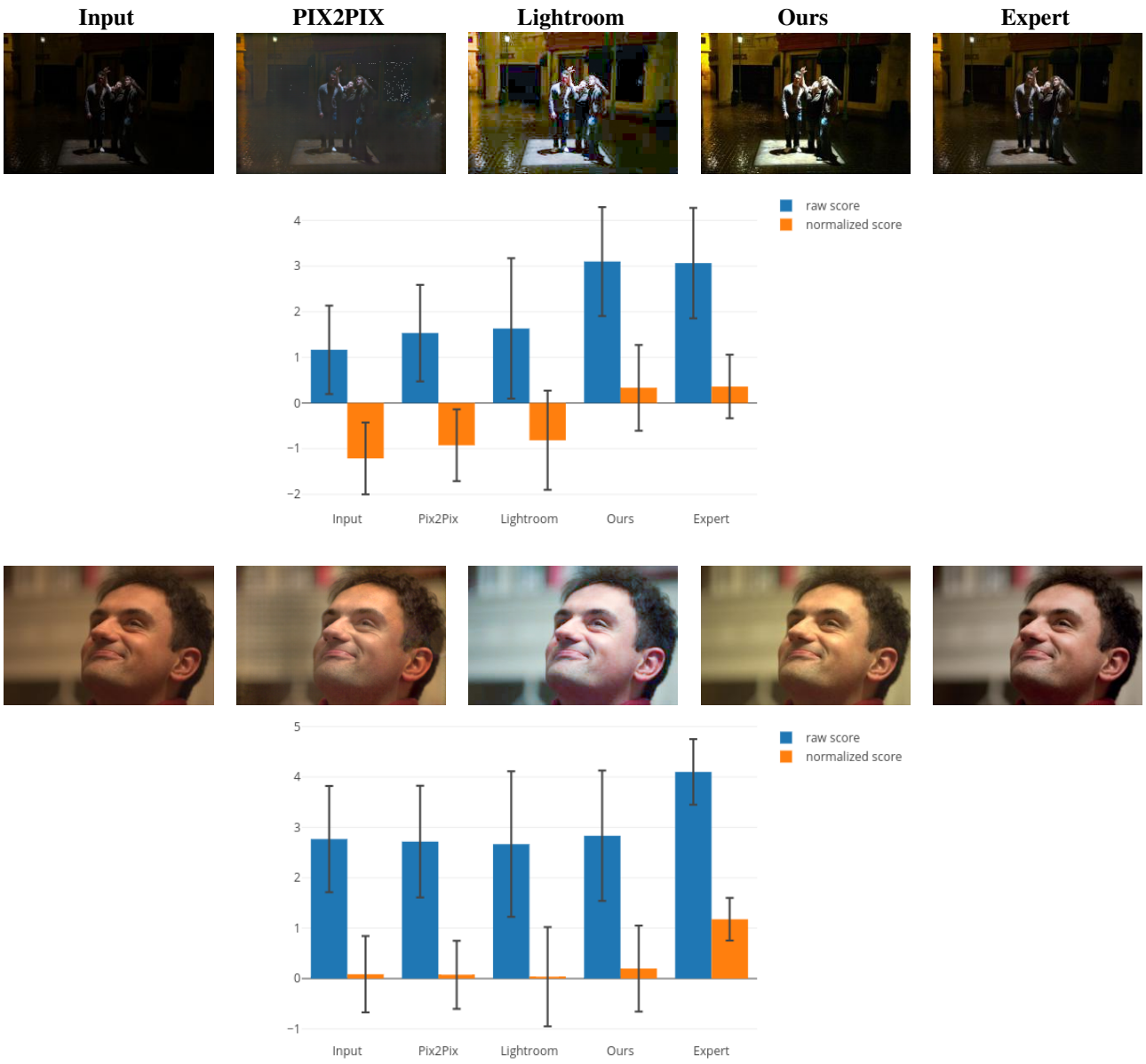


Table 15. [14 / 25] Images used in the user study.

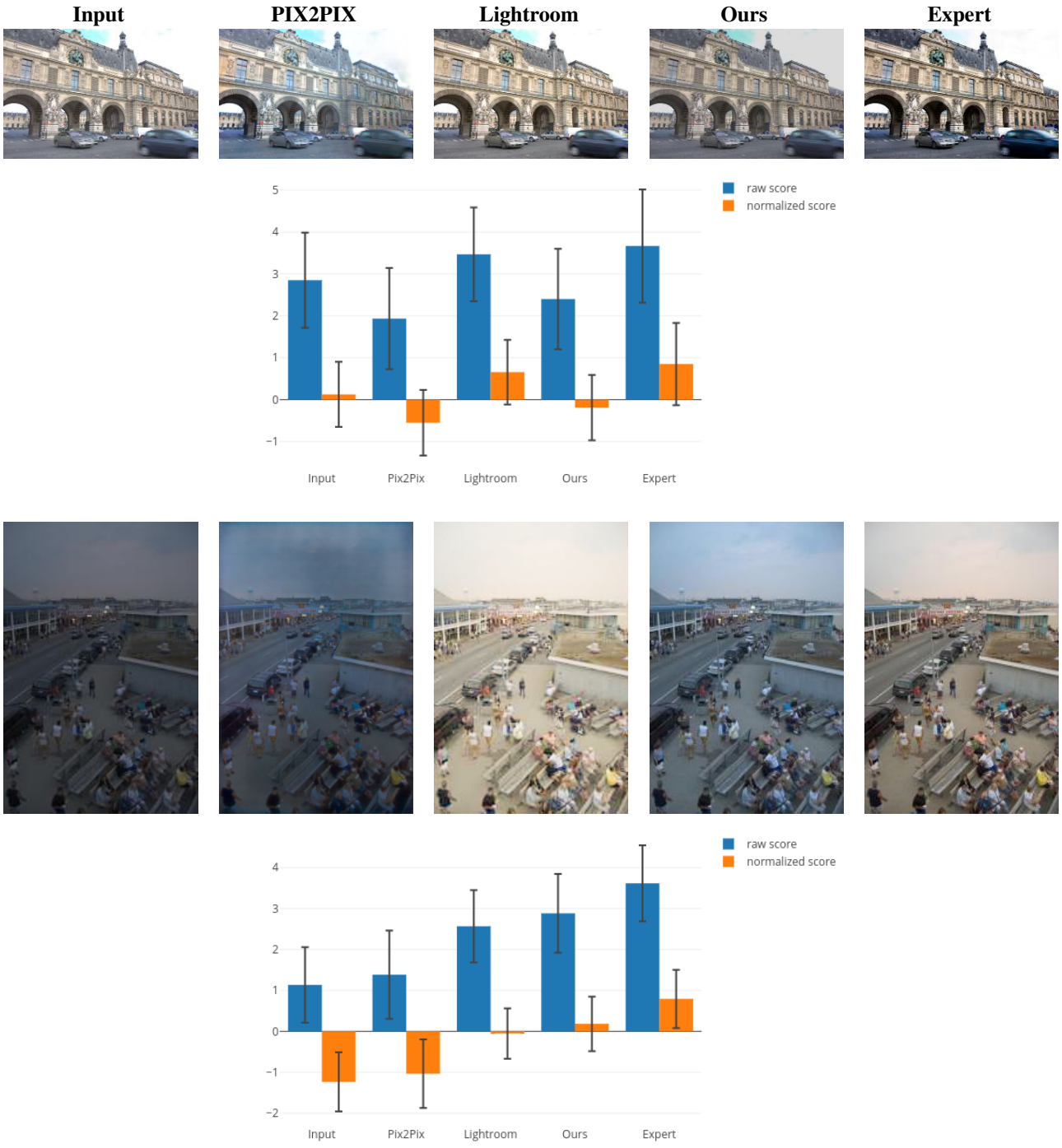


Table 16. [15 / 25] Images used in the user study.

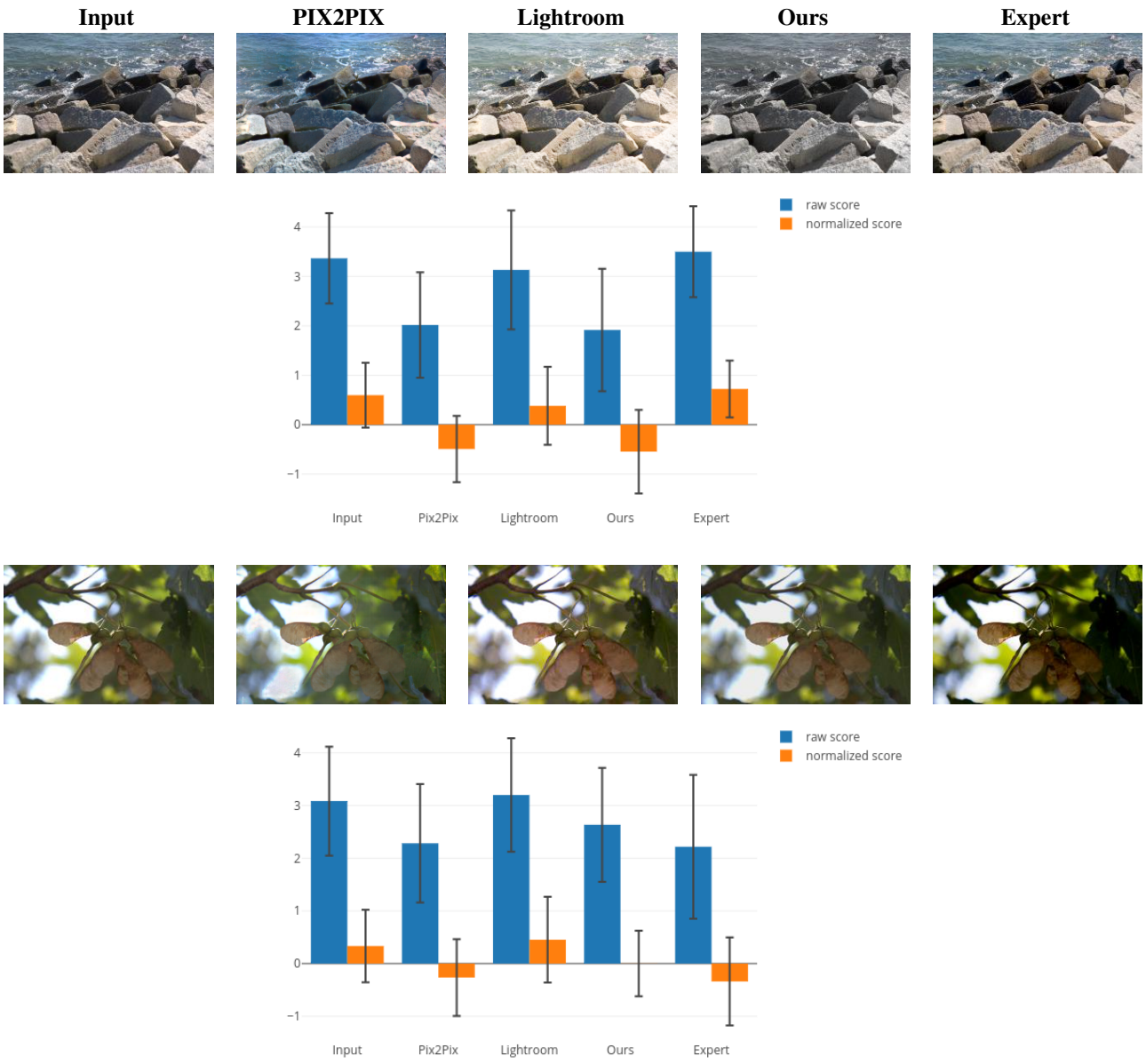


Table 17. [16 / 25] Images used in the user study.

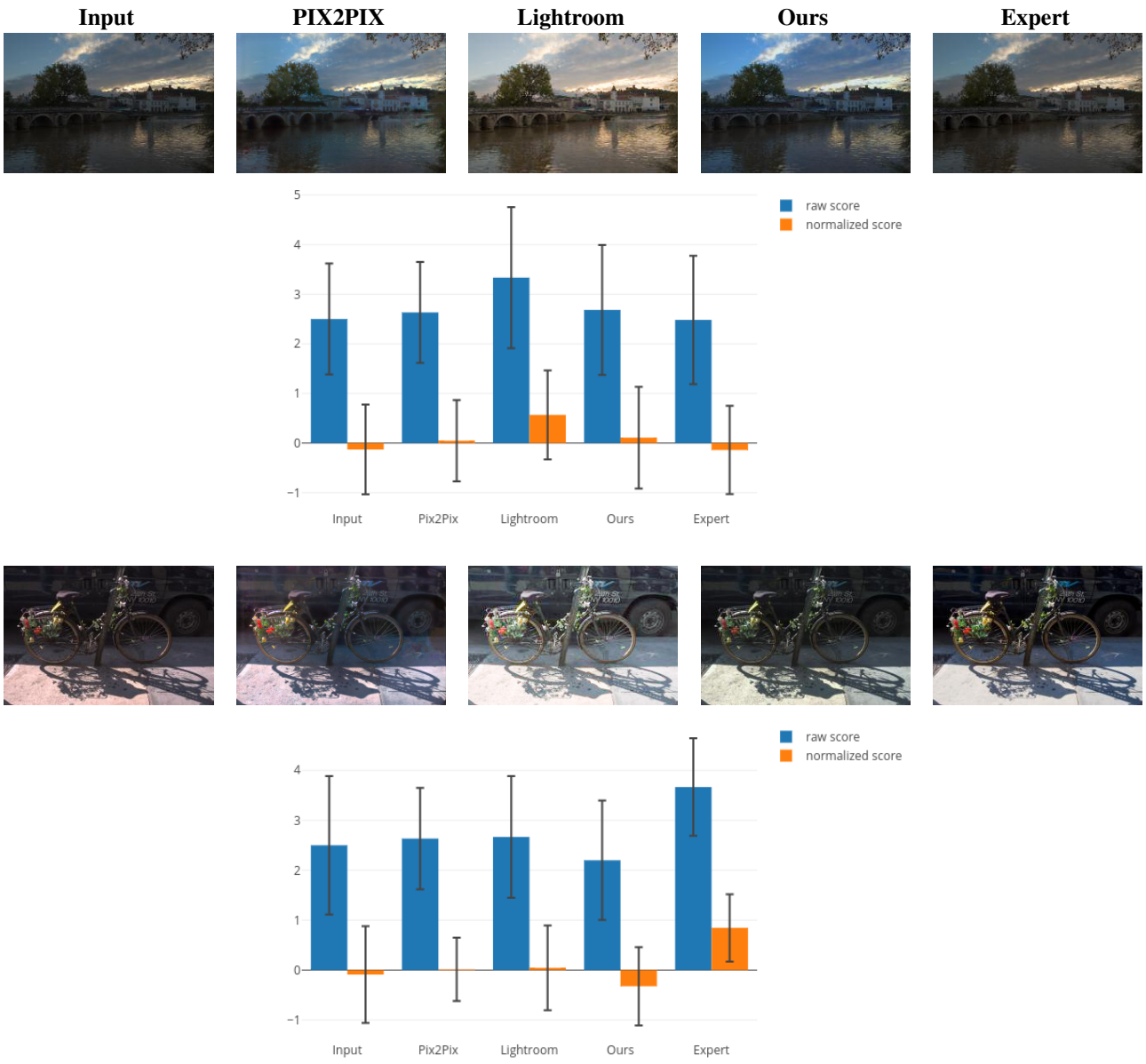


Table 18. [17 / 25] Images used in the user study.

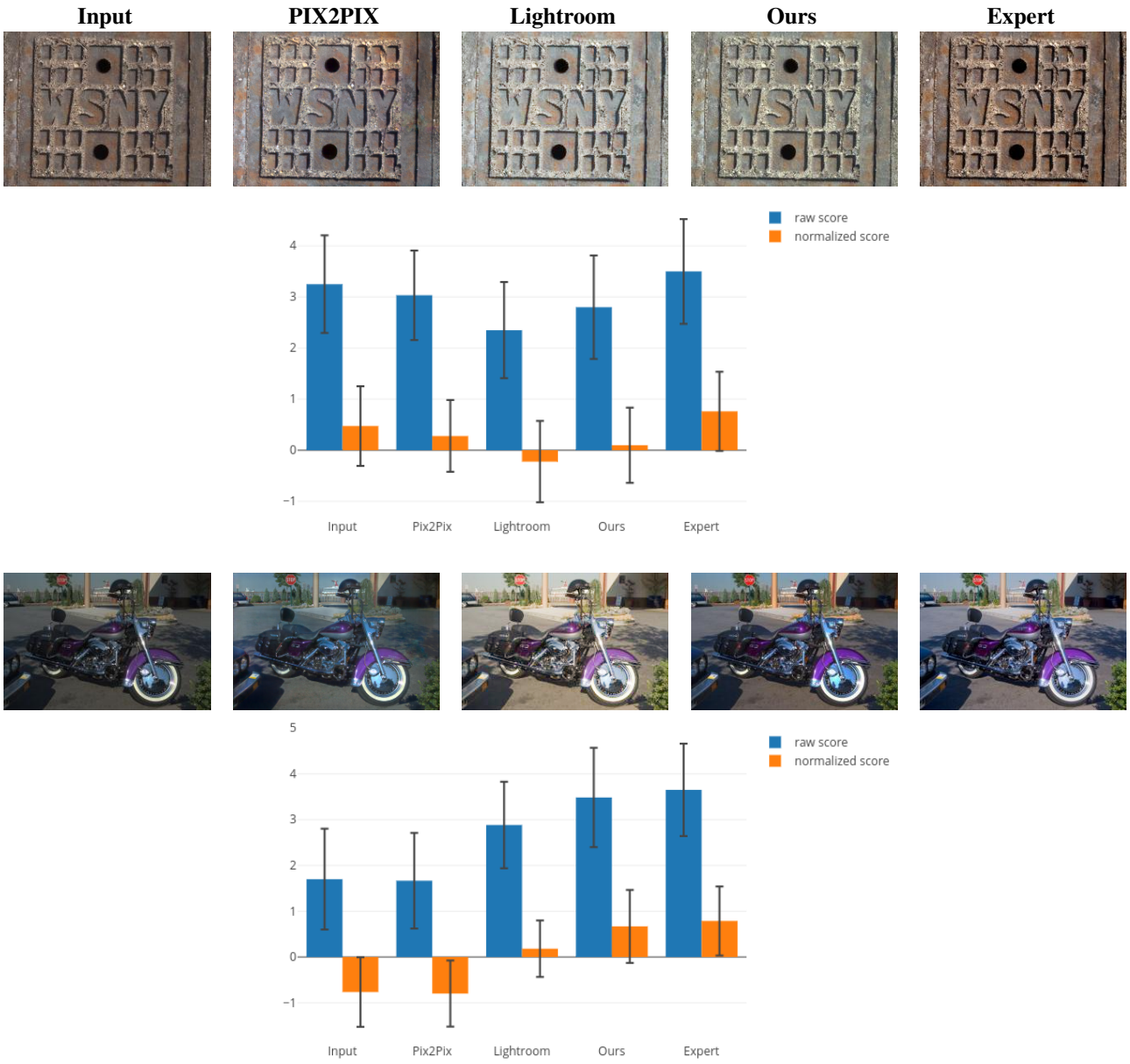


Table 19. [18 / 25] Images used in the user study.

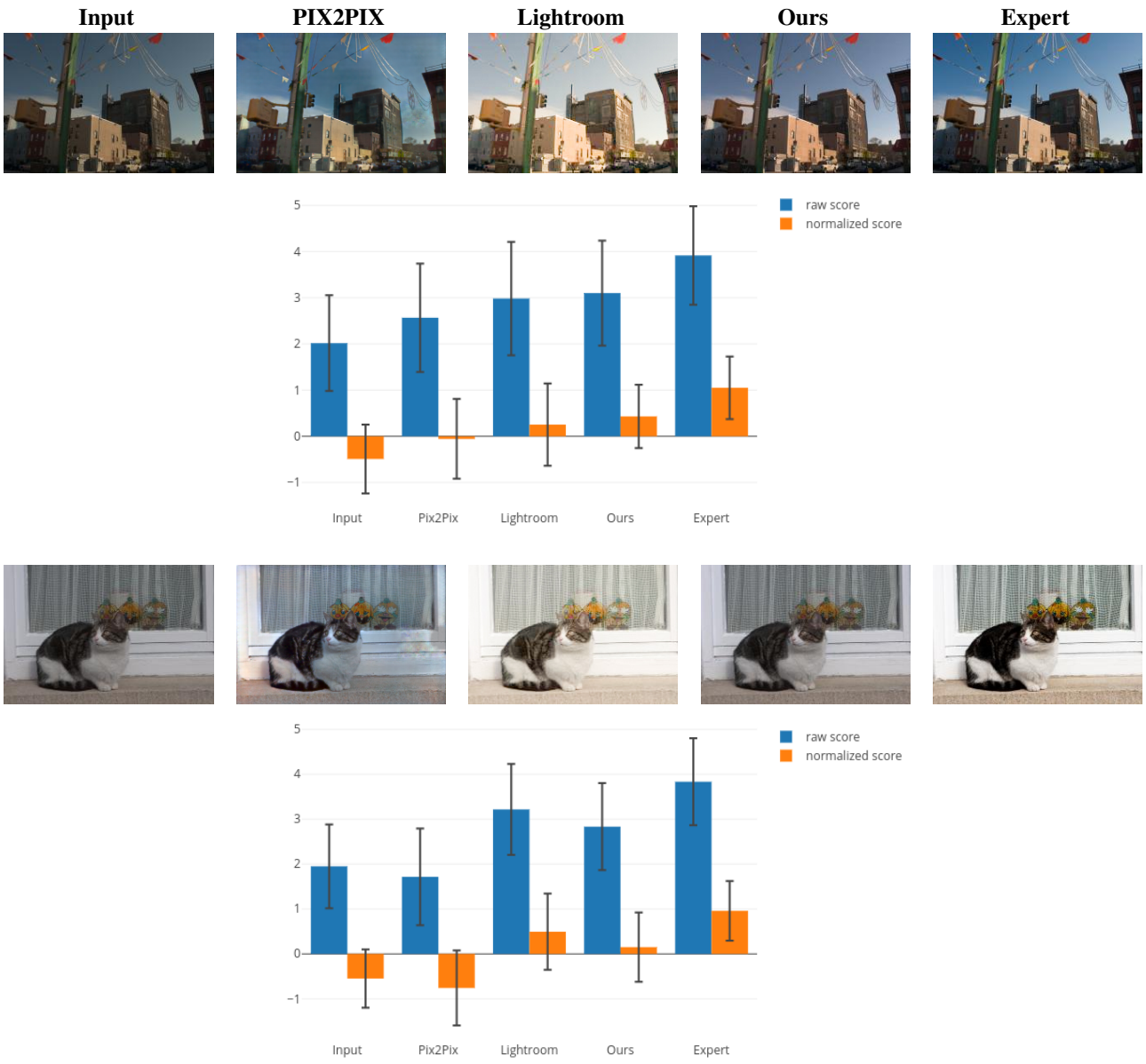


Table 20. [19 / 25] Images used in the user study.

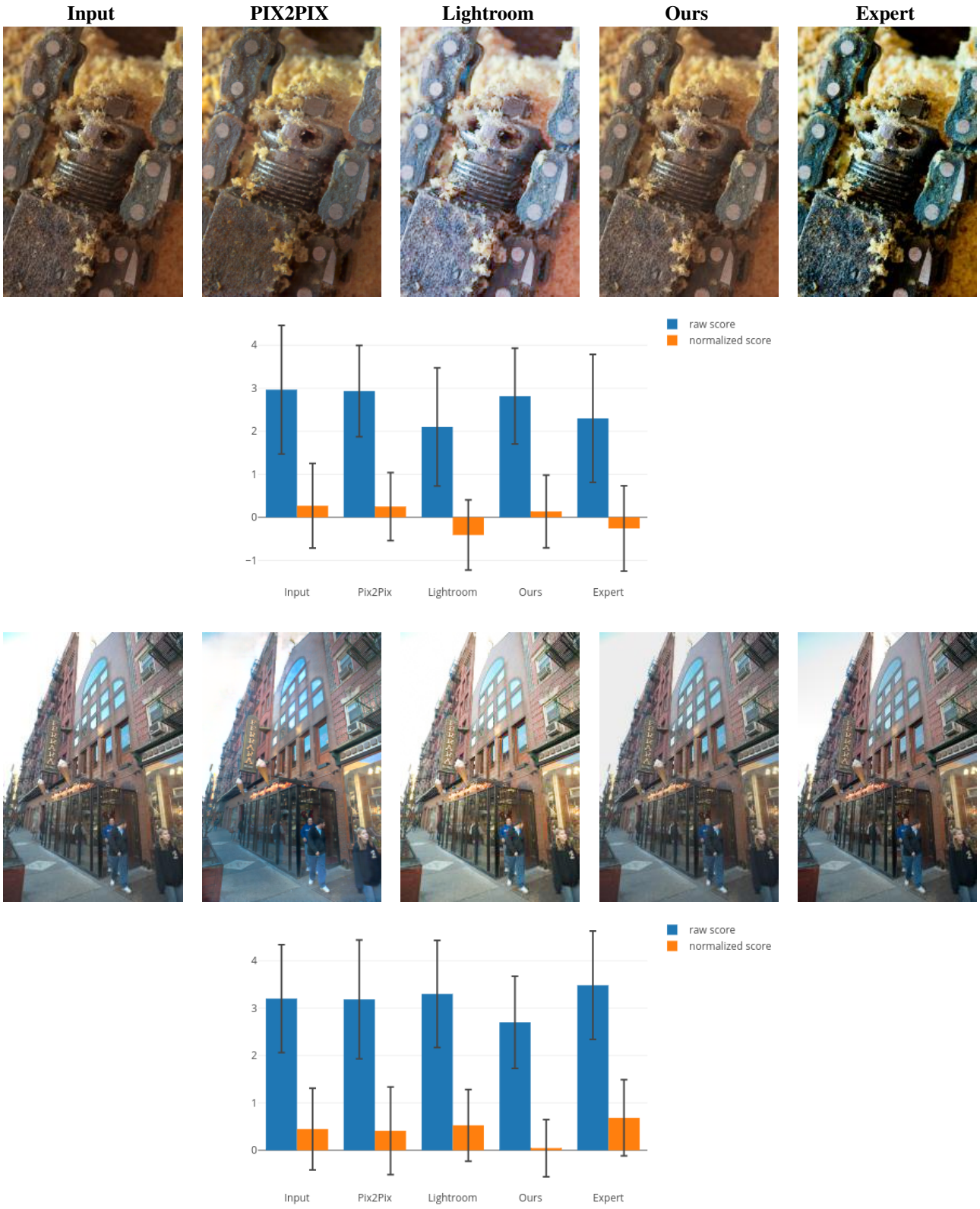


Table 21. [20 / 25] Images used in the user study.

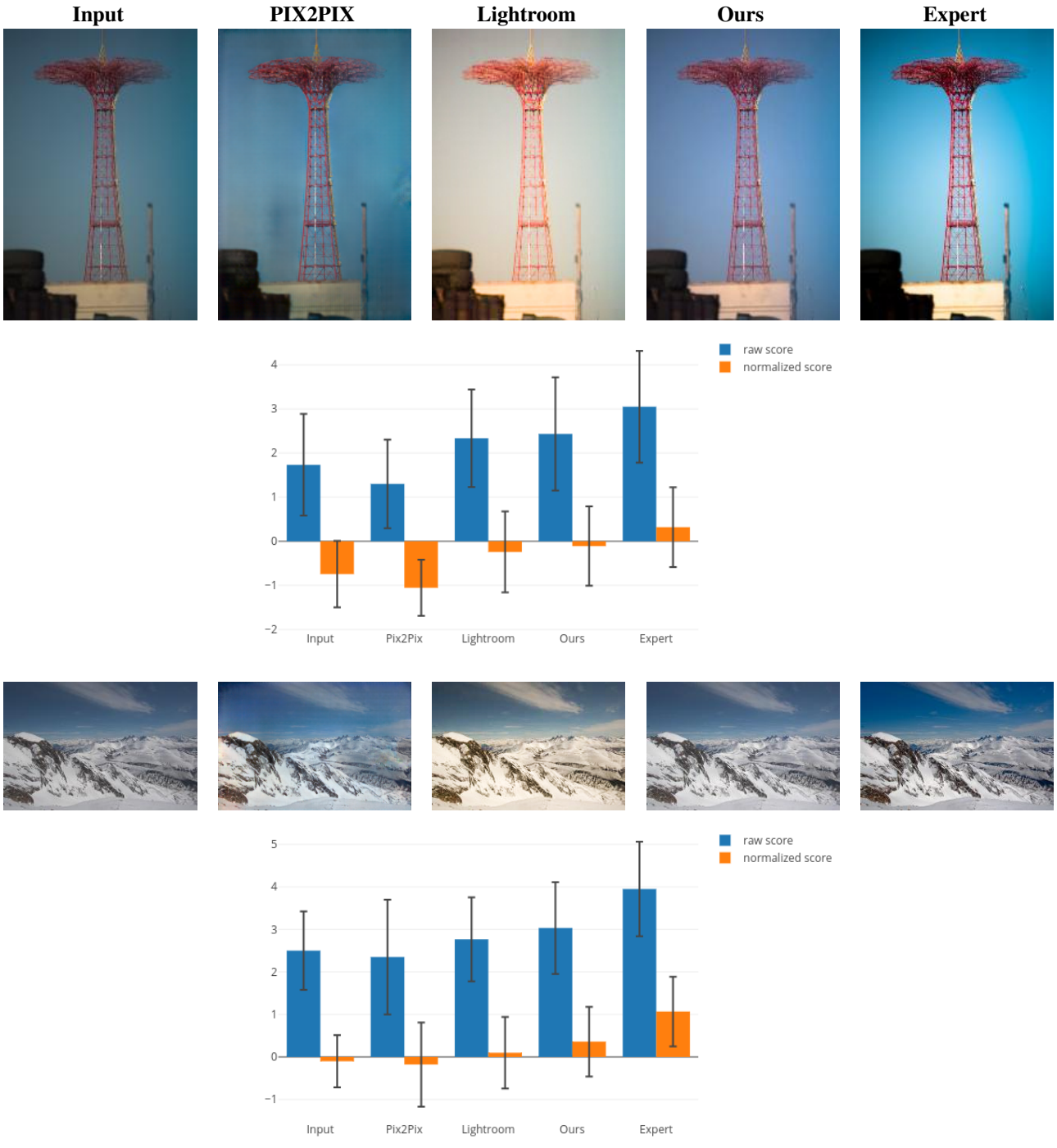


Table 22. [21 / 25] Images used in the user study.

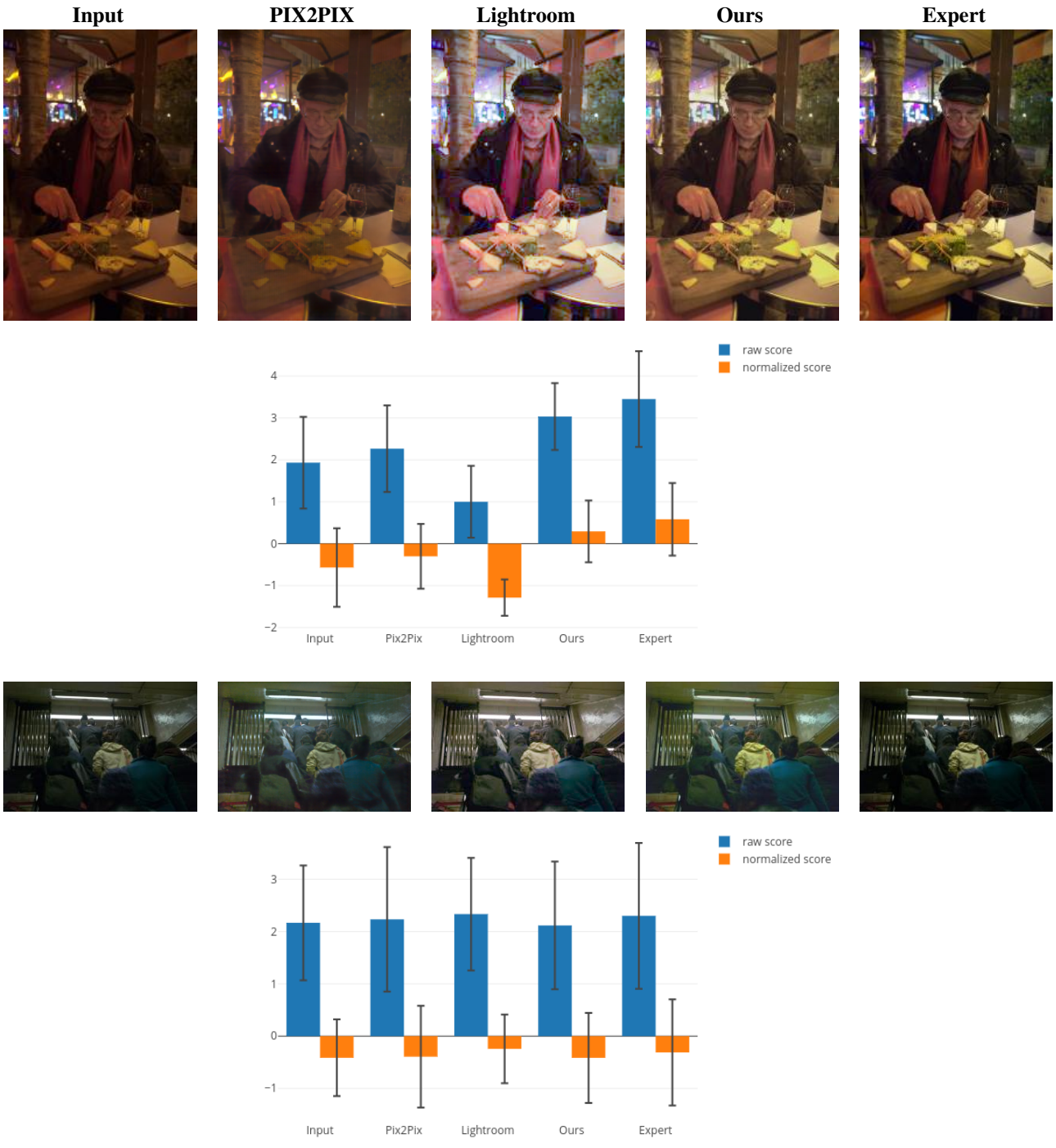


Table 23. [22 / 25] Images used in the user study.

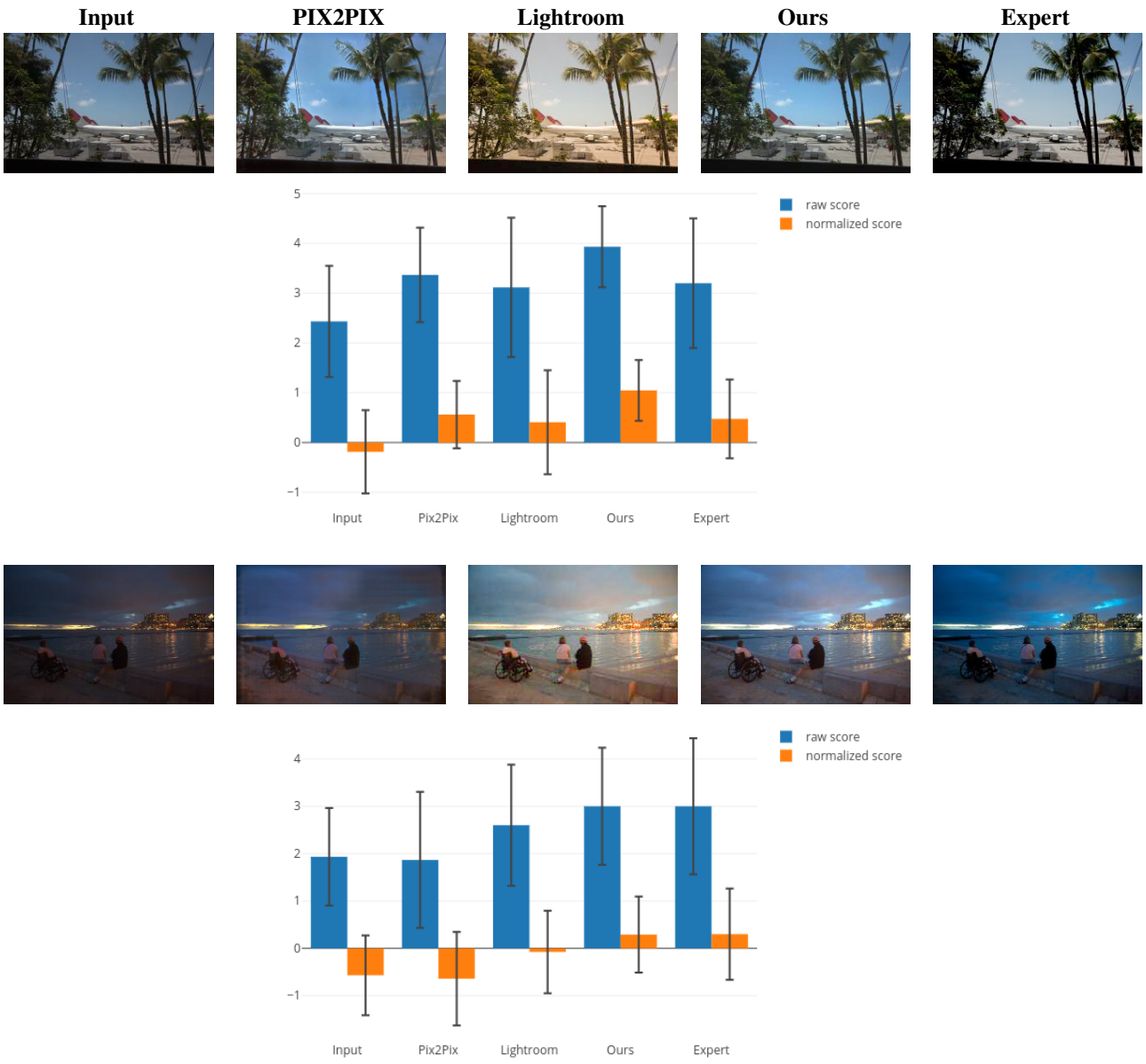


Table 24. [23 / 25] Images used in the user study.

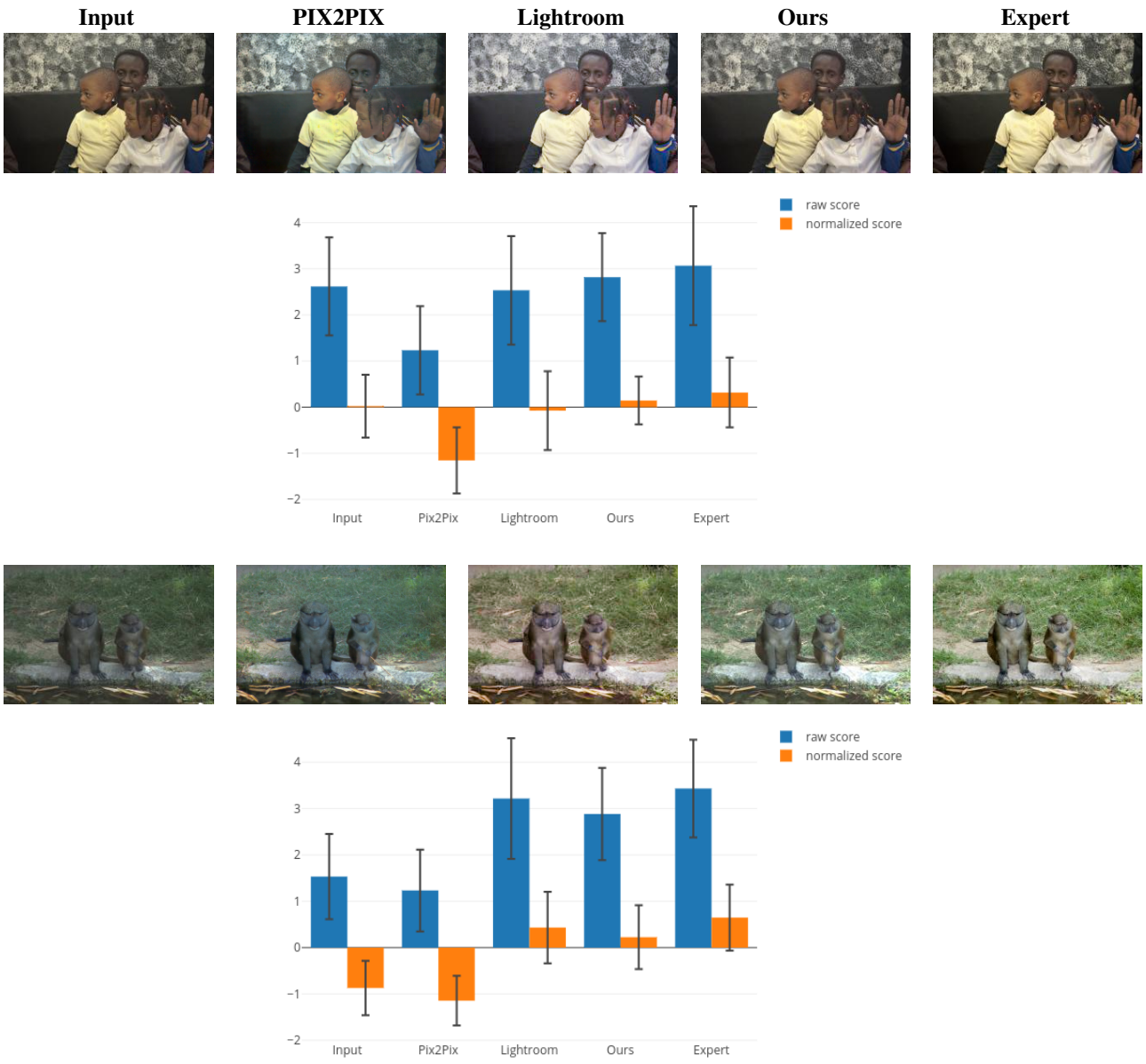


Table 25. [24 / 25] Images used in the user study.

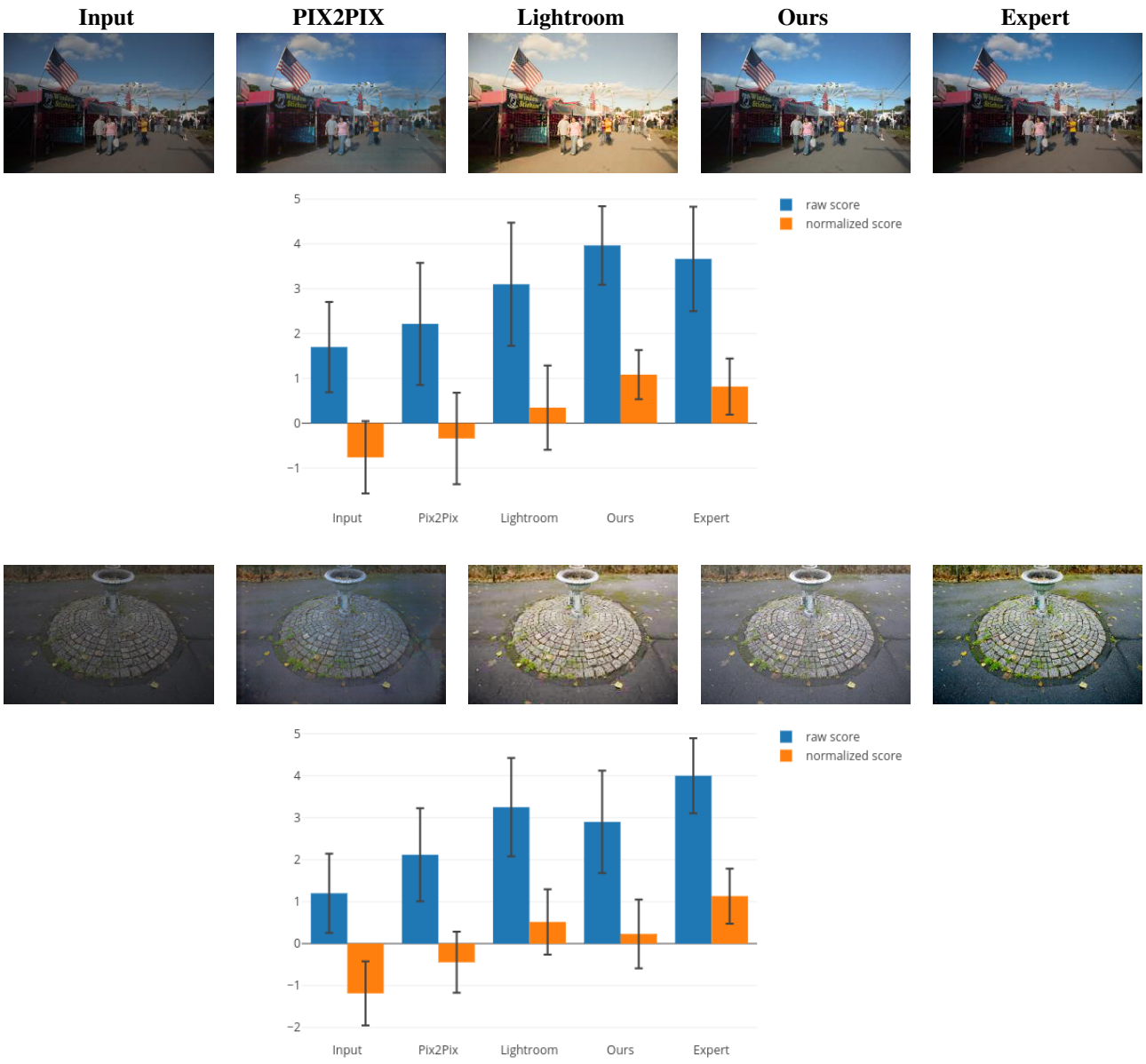


Table 26. [25 / 25] Images used in the user study.

4.2. Experiment result using input-retouched image pairs from MIT5K expert C. (with intermediate action sequences)

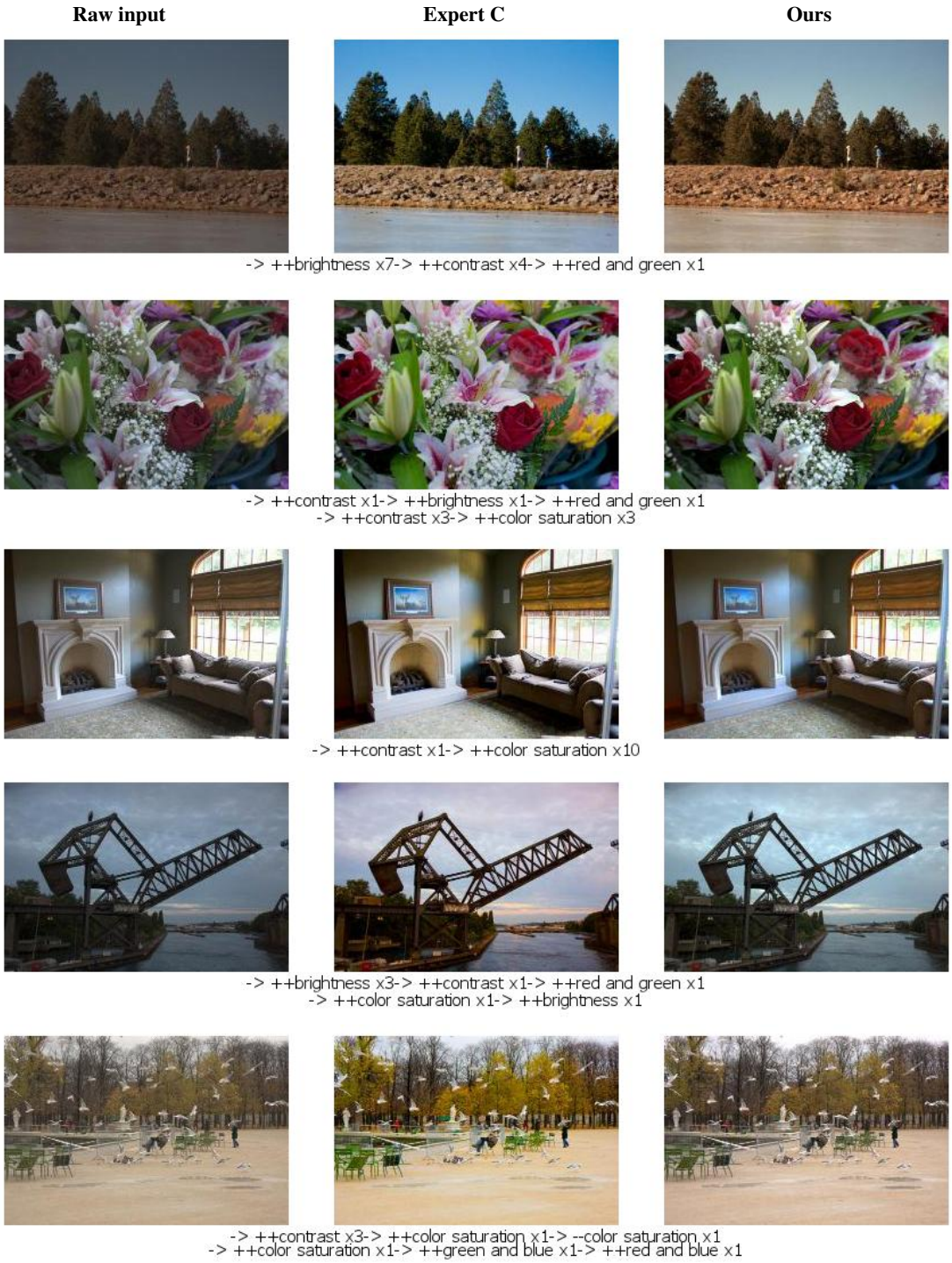


Table 27. [1 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x18		
		
-> ++contrast x7-> ++color saturation x2-> ++contrast x1 -> ++color saturation x10		
		
-> ++contrast x8-> ++color saturation x2		
		
-> ++brightness x11-> ++contrast x1-> ++brightness x1 -> ++contrast x7-> ++color saturation x1		
		
-> ++brightness x9-> ++contrast x14-> --brightness x1 -> ++contrast x1		

Table 28. [2 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x4-> ++contrast x1		
		
-> --brightness x2-> ++contrast x1-> ++color saturation x1		
		
-> ++brightness x4-> ++color saturation x3-> --color saturation x1 -> ++color saturation x3		
		
-> ++brightness x1-> ++contrast x1-> ++brightness x1 -> ++contrast x2-> ++color saturation x20		
		
-> --color saturation x1-> ++green and blue x1		

Table 29. [3 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x6-> ++contrast x5-> ++red and green x1 -> ++contrast x1		
		
-> ++brightness x5-> ++green and blue x2-> --color saturation x1 -> ++red and blue x1-> ++green and blue x1-> ++contrast x3		
		
	-> ++brightness x4-> ++contrast x10	
		
	-> ++brightness x1-> ++contrast x7	
		
	-> ++brightness x1-> ++contrast x5-> ++color saturation x13	

Table 30. [4 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x9-> ++contrast x9-> --brightness x1 -> ++contrast x1		
		
-> ++brightness x5-> ++green and blue x1-> ++brightness x1 -> ++contrast x2-> --color saturation x1-> ++contrast x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++contrast x1 -> --color saturation x1		
		
-> ++brightness x4-> ++contrast x9-> ++red and blue x1 -> ++contrast x2-> ++color saturation x1		
		
-> ++brightness x2-> ++contrast x2-> ++red and green x1 -> ++contrast x1-> ++color saturation x5		
		
-> ++brightness x4-> ++contrast x1-> ++brightness x2 -> ++contrast x4-> ++color saturation x1-> ++brightness x1-> ++color saturation x1		

Table 31. [5 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x1-> ++brightness x1-> ++contrast x2 -> ++color saturation x2-> ++contrast x1-> ++color saturation x2		
		
-> ++contrast x9-> ++color saturation x1-> ++brightness x1 -> --color saturation x2		
		
-> ++brightness x6-> ++contrast x2-> ++red and green x1 -> ++contrast x1-> ++color saturation x8		
		
-> ++brightness x3-> ++contrast x1-> ++color saturation x1 -> ++brightness x1-> ++color saturation x13		
		
-> ++brightness x3-> ++contrast x8-> ++color saturation x1		

Table 32. [6 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x1-> ++contrast x7		
		
-> ++green and blue x1-> --red and green x1-> ++green and blue x1 -> ++red and blue x1-> ++contrast x1-> ++green and blue x1-> ++contrast x2		
		
-> ++brightness x4-> ++contrast x1-> ++brightness x2 -> ++color saturation x1-> ++brightness x2-> ++color saturation x3		
		
-> ++brightness x1-> ++contrast x5-> ++brightness x1 -> ++contrast x8		
		
-> ++brightness x3-> ++contrast x16-> --red and blue x1		

Table 33. [7 / 65] Intermediate action sequence chosen by our agent.

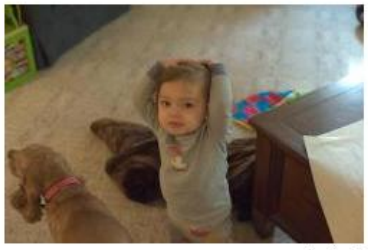
Raw input	Expert C	Ours
		
-> ++contrast x3-> --brightness x1-> ++contrast x2		
		
-> ++brightness x5-> ++contrast x1-> ++brightness x1 -> ++color saturation x1-> ++red and green x1-> ++contrast x1		
		
-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x4-> ++red and green x1-> --color saturation x1		
		
-> ++brightness x1-> ++contrast x10-> ++color saturation x1		
		
-> ++contrast x1-> ++green and blue x1-> ++red and blue x1 -> ++green and blue x1-> ++red and blue x1-> ++green and blue x1		

Table 34. [8 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x9-> ++contrast x1-> ++brightness x1 -> ++contrast x5-> ++color saturation x1		
		
-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x1-> ++color saturation x7		
		
-> ++brightness x1-> ++contrast x1-> ++brightness x1 -> ++contrast x2-> ++color saturation x7-> ++contrast x1-> ++color saturation x10		
		
-> ++brightness x8-> ++contrast x1-> ++brightness x1 -> ++contrast x3-> ++color saturation x1-> ++brightness x1		
		
-> ++brightness x8-> ++contrast x8-> ++red and green x1		

Table 35. [9 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x1-> ++brightness x1-> ++color saturation x6 -> ++contrast x1-> ++color saturation x1-> ++brightness x1-> ++color saturation x6		
		
-> ++contrast x1-> ++brightness x1-> ++contrast x2 -> ++color saturation x9		
		
-> ++brightness x4-> ++contrast x1-> ++brightness x2 -> ++contrast x6-> ++color saturation x1		
		
-> ++brightness x4-> ++contrast x1-> ++brightness x1 -> ++contrast x7		
		
-> ++contrast x11-> ++brightness x1-> ++contrast x2 -> ++red and green x1-> ++contrast x2		

Table 36. [10 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x12-> ++color saturation x1-> --color saturation x4		
		
-> ++contrast x7-> ++color saturation x3		
		
-> ++contrast x1-> ++brightness x1-> ++color saturation x5		
		
-> ++contrast x6-> ++color saturation x8		
		
-> ++contrast x1-> ++red and green x1-> ++contrast x1 -> ++green and blue x1-> ++contrast x1		

Table 37. [11 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x4-> ++contrast x1-> ++brightness x1 -> ++contrast x13-> ++red and green x1-> ++contrast x2		
		
-> ++brightness x5-> ++contrast x7		
		
-> ++contrast x2-> ++brightness x1-> ++contrast x3		
		
-> --brightness x3-> ++contrast x1-> ++color saturation x1 -> ++brightness x1-> --color saturation x1		
		
-> --color saturation x12-> ++green and blue x1-> --red and green x1 -> ++green and blue x1-> ++red and blue x1-> ++contrast x3-> ++color saturation x7		

Table 38. [12 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x5-> ++contrast x1-> ++brightness x1 -> ++color saturation x1-> ++brightness x2		
		
-> ++contrast x1-> ++brightness x1-> ++contrast x3 -> ++color saturation x1		
		
-> ++brightness x3-> ++contrast x1-> ++color saturation x4		
		
-> ++brightness x6-> ++contrast x1-> ++brightness x1 -> ++contrast x6-> ++color saturation x1-> ++brightness x1-> ++color saturation x7		
		
-> ++contrast x8-> ++color saturation x8		

Table 39. [13 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x1-> ++contrast x10-> ++color saturation x1 -> --color saturation x1		
		
-> ++brightness x6-> ++contrast x5		
		
-> ++brightness x1-> ++red and green x1-> ++contrast x1 -> ++color saturation x2		
		
-> ++brightness x1-> ++contrast x1-> ++brightness x2 -> ++contrast x4-> ++color saturation x1		
		
-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x2-> ++color saturation x1		

Table 40. [14 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++brightness x3-> ++contrast x5	
		
	-> ++green and blue x1-> ++red and blue x1-> ++green and blue x1 -> --color saturation x1-> ++color saturation x1	
		
	-> ++brightness x10-> ++contrast x1-> ++brightness x1 -> ++color saturation x9	
		
	-> ++brightness x2-> ++contrast x1-> ++brightness x4 -> ++contrast x2-> ++brightness x1-> ++color saturation x1	
		
	-> ++brightness x11-> ++contrast x2	

Table 41. [15 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++brightness x9-> ++contrast x4	
		
	-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x6-> ++color saturation x7	
		
	-> ++brightness x5-> ++red and green x1-> ++contrast x1 -> ++green and blue x1	
		
	-> ++contrast x6-> ++color saturation x4-> --color saturation x1 -> ++brightness x1-> --color saturation x2	
		
	-> ++brightness x10-> ++contrast x1	

Table 42. [16 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++contrast x6-> ++color saturation x2	
		
	-> ++contrast x5-> ++color saturation x3	
		
	-> ++brightness x2-> ++contrast x3	
		
	-> ++brightness x4-> ++contrast x1-> ++brightness x1	
		
	-> ++brightness x7-> ++green and blue x1-> ++contrast x3 -> ++color saturation x1	

Table 43. [17 / 65] Intermediate action sequence chosen by our agent.

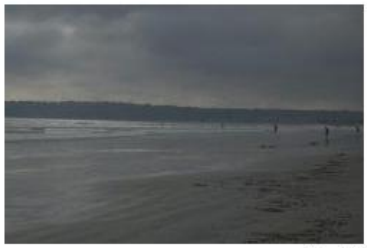
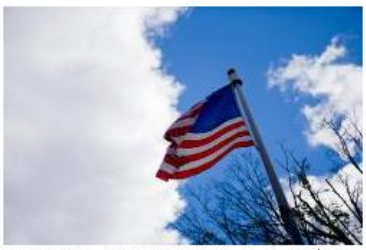
Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x1-> ++brightness x1 -> ++contrast x3-> ++color saturation x1		
		
-> ++brightness x7-> ++contrast x2-> ++color saturation x12		
		
-> ++brightness x1-> ++color saturation x7		
		
-> ++contrast x15-> --brightness x1-> ++contrast x1 -> ++color saturation x1		
		
-> --brightness x1-> ++contrast x1-> ++color saturation x1		

Table 44. [18 / 65] Intermediate action sequence chosen by our agent.

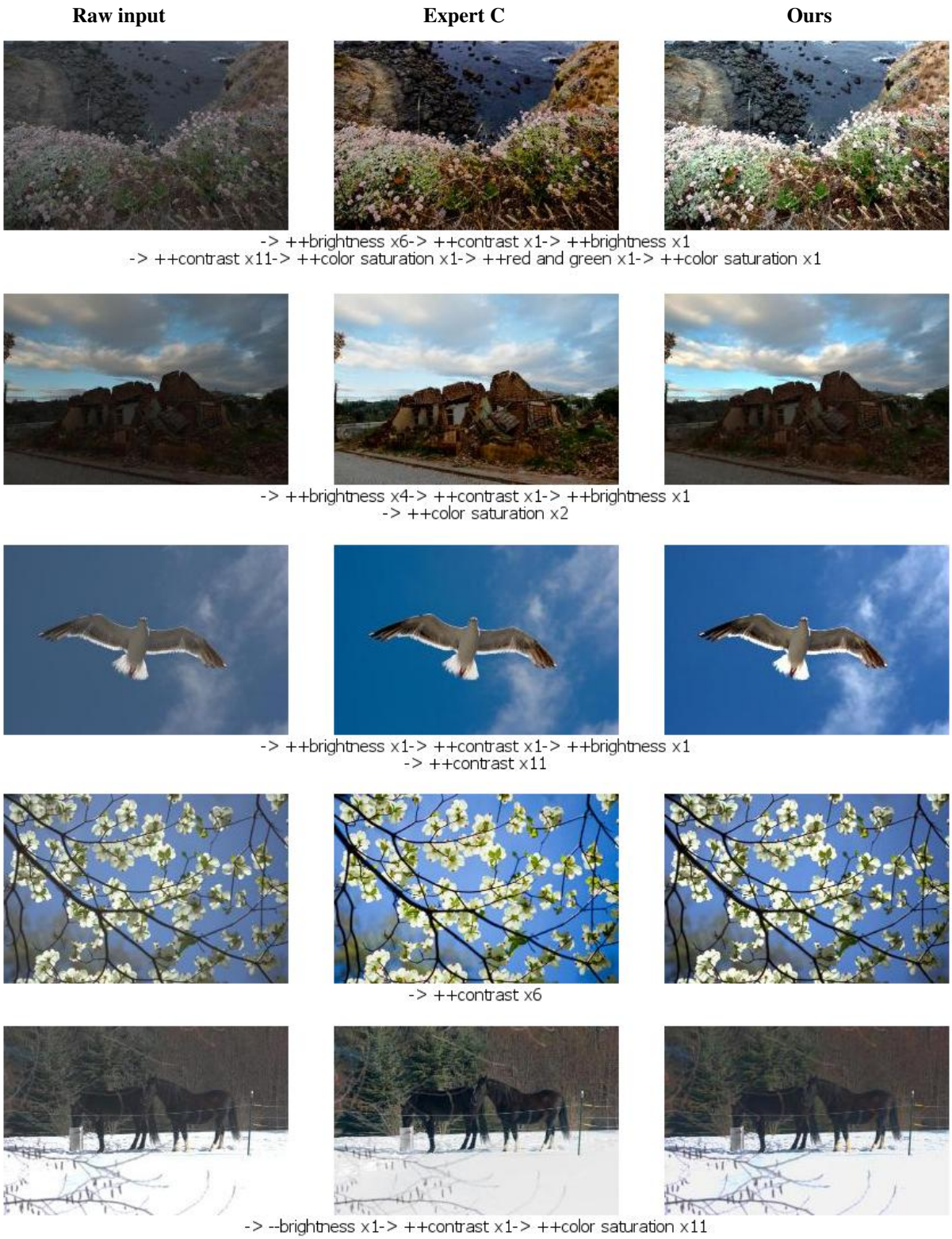


Table 45. [19 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++brightness x2-> ++contrast x6	
		
	-> ++contrast x1-> ++brightness x1-> ++contrast x2 -> ++color saturation x1-> ++brightness x1	
		
	-> ++brightness x1-> ++contrast x6-> ++color saturation x1	
		
	-> ++brightness x7-> ++contrast x1-> ++brightness x1 -> ++contrast x1-> ++color saturation x9-> ++contrast x1-> ++color saturation x2 -> ++brightness x1-> ++color saturation x13-> ++contrast x1-> ++green and blue x1	
		
	-> ++contrast x3-> ++green and blue x1-> ++color saturation x1 -> ++contrast x1-> ++color saturation x4	

Table 46. [20 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x7-> ++contrast x1-> ++brightness x1 -> ++contrast x1-> ++color saturation x2		
		
-> ++contrast x1-> ++green and blue x1-> ++red and blue x1 -> ++green and blue x2-> ++contrast x5-> ++red and blue x1-> ++green and blue x1		
		
-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x3-> ++color saturation x3		
		
-> ++brightness x7-> ++color saturation x1		
		
-> --color saturation x14-> ++green and blue x1-> --color saturation x6 -> ++red and blue x1-> --color saturation x2-> ++green and blue x3-> ++red and blue x1 -> ++green and blue x1-> ++contrast x1-> ++color saturation x1		

Table 47. [21 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x4-> ++color saturation x6		
		
-> ++brightness x7-> ++contrast x10-> ++color saturation x5		
		
-> ++brightness x4-> ++contrast x8-> --color saturation x1 -> ++color saturation x1		
		
-> ++contrast x1-> ++color saturation x9		
		
-> ++brightness x3-> ++contrast x5-> ++green and blue x1		

Table 48. [22 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x1-> ++brightness x1-> ++contrast x6 -> ++color saturation x2		
		
-> ++brightness x1-> ++contrast x3-> ++color saturation x1		
		
-> ++brightness x6-> ++contrast x1-> ++brightness x1 -> ++contrast x15		
		
-> --brightness x1-> ++contrast x2-> ++color saturation x6		
		
-> ++contrast x4-> ++brightness x1-> ++contrast x6 -> ++color saturation x1-> ++brightness x2-> ++green and blue x1		

Table 49. [23 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++contrast x1	
		
	-> ++brightness x7-> ++contrast x1-> ++brightness x1 -> ++contrast x2-> ++red and blue x1-> ++contrast x3-> ++color saturation x1	
		
	-> ++contrast x10-> ++brightness x1-> ++red and green x1	
		
	-> ++contrast x9-> ++green and blue x1-> ++color saturation x3	
		
	-> ++brightness x4-> ++contrast x1-> ++red and green x1 -> ++brightness x1-> ++color saturation x1-> ++brightness x1	

Table 50. [24 / 65] Intermediate action sequence chosen by our agent.

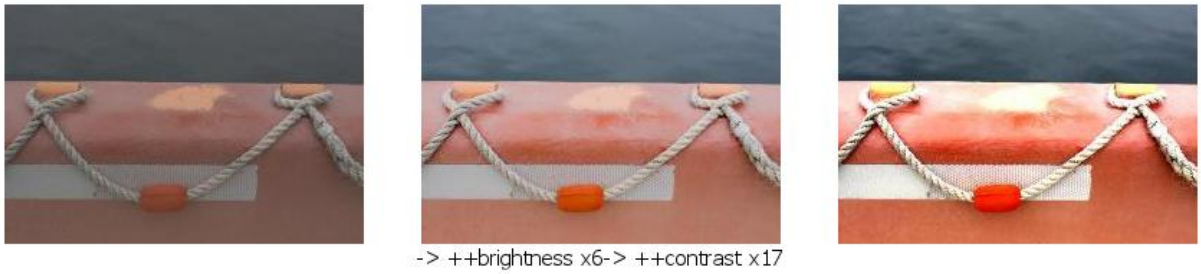
Raw input	Expert C	Ours
		
-> --brightness x1-> ++contrast x1-> ++color saturation x4		
		
-> ++contrast x2-> ++red and green x1-> ++green and blue x1 -> ++color saturation x2		
		
-> ++brightness x10-> ++contrast x1-> ++brightness x1 -> ++red and blue x1		
		
-> ++brightness x8-> ++contrast x1-> ++brightness x1 -> ++contrast x3-> ++color saturation x20-> --color saturation x1-> ++color saturation x4		
		
-> ++brightness x6-> ++contrast x17		

Table 51. [25 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x5-> ++color saturation x1-> ++brightness x1 -> ++color saturation x3		
		
-> ++brightness x2-> ++contrast x1-> ++brightness x1 -> ++contrast x1-> ++color saturation x2		
		
-> ++contrast x3-> ++green and blue x1		
		
-> ++brightness x14-> ++contrast x12		
		
-> ++contrast x1-> ++color saturation x9		

Table 52. [26 / 65] Intermediate action sequence chosen by our agent.

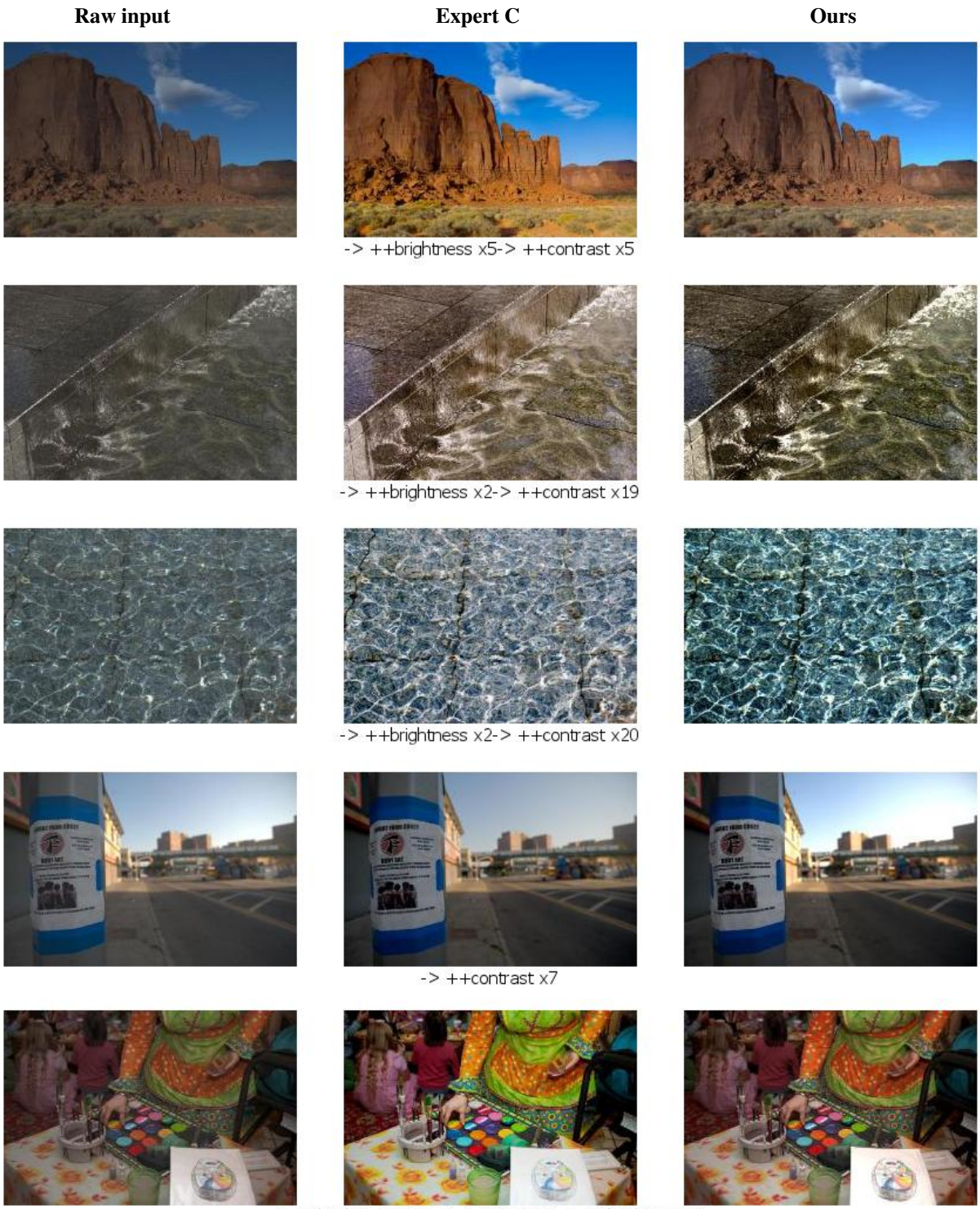


Table 53. [27 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x5-> ++contrast x6-> ++color saturation x1		
		
-> ++brightness x3-> ++contrast x13		
		
-> ++contrast x1-> ++color saturation x1-> --color saturation x4		
		
-> ++brightness x1-> ++contrast x3		
		
-> ++contrast x1-> ++brightness x1-> ++contrast x9 -> ++color saturation x9		

Table 54. [28 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> --brightness x2-> ++contrast x2		
		
-> --color saturation x4-> ++green and blue x1-> --color saturation x5 -> ++red and blue x1-> ++green and blue x1		
		
-> ++brightness x12-> ++contrast x1-> ++color saturation x5		
		
-> ++contrast x1-> ++color saturation x13		
		
-> ++brightness x4-> ++contrast x1-> ++color saturation x1 -> ++brightness x1-> ++color saturation x1		

Table 55. [29 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x1-> ++brightness x1 -> ++color saturation x6		
		
-> --red and green x1-> --color saturation x12-> ++green and blue x1 -> ++red and blue x1-> ++contrast x1-> ++color saturation x1-> ++red and green x1 -> --color saturation x7		
		
-> ++brightness x1-> ++contrast x5-> ++green and blue x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x3-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x2-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1		

Table 56. [30 / 65] Intermediate action sequence chosen by our agent.

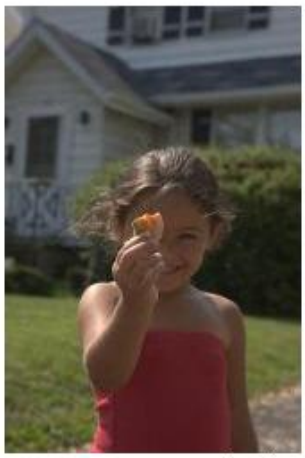
Raw input	Expert C	Ours
		
-> ++brightness x4-> ++contrast x5-> ++color saturation x2		
		
-> ++brightness x5-> ++contrast x7-> --color saturation x1 -> ++green and blue x1-> ++contrast x2		
		
-> ++brightness x1-> ++contrast x4-> ++color saturation x1 -> ++contrast x1-> ++color saturation x21		

Table 57. [31 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x8-> ++contrast x5-> ++color saturation x1		
		
-> ++contrast x1-> ++brightness x1-> ++contrast x12 -> --brightness x1		
		
-> ++brightness x5-> ++contrast x6		

Table 58. [32 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x4-> ++contrast x5-> ++color saturation x5 -> ++brightness x1-> ++color saturation x6		
		
-> ++green and blue x1-> ++red and blue x1-> ++green and blue x1 -> ++red and blue x1-> ++green and blue x1-> ++contrast x1-> ++green and blue x1 -> ++red and blue x1-> ++green and blue x1		
		
-> ++brightness x4-> ++green and blue x1-> ++red and blue x1 -> ++green and blue x1-> ++contrast x2-> ++color saturation x1		

Table 59. [33 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x1-> ++brightness x1 -> ++contrast x2-> ++color saturation x3		
		
-> ++contrast x8-> ++green and blue x1-> ++contrast x1		
		
-> ++green and blue x1-> ++red and blue x1-> ++green and blue x1 -> ++contrast x1-> ++green and blue x1-> ++red and blue x1-> ++contrast x3 -> ++green and blue x1		

Table 60. [34 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x10-> ++contrast x3-> ++color saturation x2		
		
-> ++brightness x9-> ++green and blue x2-> --color saturation x5 -> ++red and blue x1-> ++green and blue x1-> --color saturation x1-> ++green and blue x1 -> ++red and blue x1-> --color saturation x4-> ++green and blue x1-> --color saturation x24		
		
-> ++contrast x5-> ++color saturation x7		

Table 61. [35 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> --red and green x1-> --color saturation x10-> ++green and blue x1 -> ++red and blue x1-> ++contrast x2-> --color saturation x3-> ++contrast x1 -> --color saturation x2-> ++color saturation x1-> --color saturation x4-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1		
		
-> ++brightness x1-> ++contrast x1-> ++brightness x2 -> ++contrast x5-> ++color saturation x1		

Table 62. [36 / 65] Intermediate action sequence chosen by our agent.

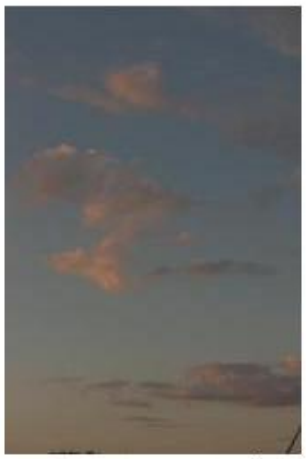
Raw input	Expert C	Ours
		
-> ++brightness x5-> ++contrast x3-> ++color saturation x2		
		
-> ++contrast x1-> ++color saturation x1-> ++brightness x1		
		
-> ++brightness x4-> ++contrast x1-> ++brightness x1 -> ++contrast x24-> --brightness x1-> ++contrast x3-> --red and green x1		

Table 63. [37 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x2-> ++red and blue x1-> ++green and blue x1 -> ++red and blue x1-> ++contrast x3-> ++green and blue x1-> ++contrast x4 -> ++green and blue x1-> ++contrast x3		
		
-> ++brightness x2-> ++contrast x6-> ++color saturation x1		
		
-> ++brightness x4-> ++contrast x1-> ++brightness x1 -> ++contrast x2-> ++color saturation x1-> ++brightness x1-> ++color saturation x4		

Table 64. [38 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x8-> ++contrast x10		
		
-> ++brightness x6-> ++contrast x1-> ++color saturation x5		
		
-> ++contrast x1-> ++green and blue x1		

Table 65. [39 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x6-> ++color saturation x7		
		
-> --brightness x1-> ++contrast x2-> --brightness x1 -> ++contrast x2-> --brightness x1-> ++contrast x1-> ++color saturation x2		
		
-> ++red and blue x1-> ++green and blue x1-> ++red and blue x1 -> ++green and blue x1-> ++red and blue x1-> ++green and blue x1-> ++red and blue x1 -> ++green and blue x1-> ++contrast x1-> ++green and blue x1-> ++color saturation x3		

Table 66. [40 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x1-> ++brightness x1-> ++contrast x1 -> ++color saturation x12		
		
-> --color saturation x1-> ++green and blue x1-> --color saturation x1 -> ++red and blue x1-> ++green and blue x1-> --color saturation x2-> ++contrast x1		
		
-> ++brightness x1-> ++contrast x5-> ++brightness x1 -> ++contrast x10-> ++color saturation x1		

Table 67. [41 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x6-> ++color saturation x28		
		
-> ++brightness x7-> --color saturation x1-> ++green and blue x1 -> ++red and blue x1-> --color saturation x2-> ++green and blue x1-> ++red and blue x1 -> --color saturation x5-> ++green and blue x1-> --brightness x1-> ++contrast x1		
		
-> ++brightness x12-> ++contrast x3-> ++color saturation x3		

Table 68. [42 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x7-> ++contrast x1-> ++brightness x1 -> ++contrast x1-> ++color saturation x5		
		
-> ++brightness x3-> ++contrast x3-> ++color saturation x1		
		
-> ++brightness x10-> ++contrast x1-> ++brightness x1 -> ++color saturation x1-> ++brightness x2-> ++color saturation x1		

Table 69. [43 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x5-> ++color saturation x1-> ++brightness x1-> ++color saturation x6		
		
-> --color saturation x4-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x2-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1		

Table 70. [44 / 65] Intermediate action sequence chosen by our agent.

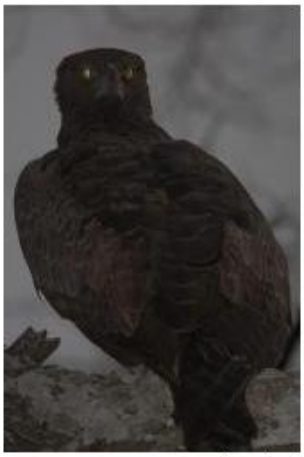
Raw input	Expert C	Ours
		
-> ++contrast x2-> ++color saturation x1		
		
-> ++brightness x8-> ++contrast x3-> ++color saturation x16		
		
-> ++brightness x2-> ++contrast x1-> ++brightness x1 -> ++color saturation x1-> ++brightness x1-> ++color saturation x1		

Table 71. [45 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x7-> ++contrast x1-> ++brightness x1 -> ++contrast x3-> ++color saturation x7		
		
-> ++contrast x6-> ++brightness x1-> ++color saturation x9		
		
-> --color saturation x2-> ++green and blue x1-> --color saturation x6 -> ++red and blue x1-> ++green and blue x1-> ++contrast x1-> ++color saturation x3 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x2-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1		

Table 72. [46 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
		
-> ++brightness x6-> ++contrast x5-> ++red and green x1		
		
-> ++brightness x4-> ++contrast x2-> ++color saturation x2		

Table 73. [47 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		

-> ++contrast x2-> --color saturation x2-> ++color saturation x1
-> --color saturation x1-> ++color saturation x2-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x2
-> --color saturation x1-> ++color saturation x1-> --color saturation x1

-> ++brightness x1-> ++contrast x10-> ++color saturation x10

Table 74. [48 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x10-> ++color saturation x1		
		
-> ++contrast x1-> ++color saturation x1-> ++brightness x1 -> ++color saturation x1		
		
-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x4-> ++color saturation x1		

Table 75. [49 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++green and blue x1-> ++red and blue x1 -> ++green and blue x2-> ++red and blue x1-> ++green and blue x1-> --color saturation x1 -> ++contrast x1		
		
-> ++green and blue x1-> --color saturation x3-> ++green and blue x1 -> --color saturation x1-> ++red and blue x1-> ++green and blue x1-> --color saturation x2 -> ++red and blue x1-> ++green and blue x1-> ++red and blue x1-> ++green and blue x1 -> ++red and blue x1-> ++green and blue x1-> ++red and blue x1-> ++green and blue x2 -> ++red and blue x1-> ++green and blue x1-> ++contrast x2-> ++red and blue x1 -> ++green and blue x1-> ++color saturation x1-> ++green and blue x1-> ++color saturation x2 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1		
		
-> ++brightness x3-> ++contrast x1-> ++red and green x1 -> ++color saturation x1-> ++brightness x1-> ++color saturation x9		

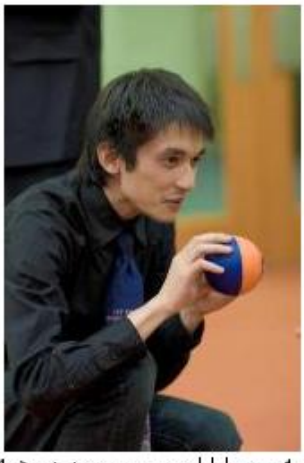
Table 76. [50 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x7-> ++red and green x1 -> ++color saturation x2		
		
-> ++green and blue x1-> ++red and blue x1-> ++green and blue x1		
		
-> ++color saturation x5		

Table 77. [51 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x5-> ++contrast x1-> ++green and blue x1 -> ++brightness x1-> ++red and blue x1		
		
-> ++contrast x9-> ++color saturation x1		
		
-> ++brightness x5-> ++contrast x1-> ++brightness x1 -> ++color saturation x9		

Table 78. [52 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x6-> ++color saturation x3		
		
-> ++brightness x3-> ++green and blue x2-> ++color saturation x3		
		
-> --color saturation x4-> ++green and blue x1-> --color saturation x5		

-> ++contrast x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x2
-> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1
-> --color saturation x1-> ++color saturation x1-> --color saturation x1

Table 79. [53 / 65] Intermediate action sequence chosen by our agent.

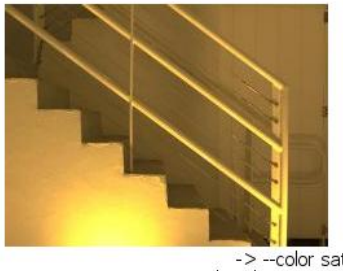
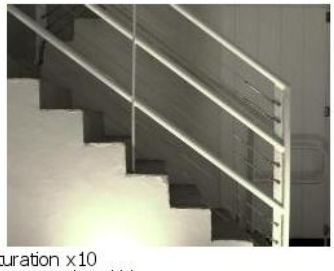
Raw input	Expert C	Ours
		
-> ++brightness x1-> ++green and blue x1-> ++color saturation x4		
		
-> --color saturation x8-> ++green and blue x1-> --color saturation x10 -> --red and green x1-> ++green and blue x1-> --color saturation x6-> ++red and blue x1 -> ++green and blue x1-> ++contrast x5		
		
-> ++contrast x6-> ++red and green x1-> ++contrast x1 -> ++color saturation x12-> --color saturation x1-> ++color saturation x2-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x2-> --color saturation x2 -> ++color saturation x1-> --color saturation x1-> ++color saturation x2-> --color saturation x1 -> ++color saturation x1-> --color saturation x1-> ++color saturation x1		
		
-> --color saturation x4-> ++green and blue x1-> --color saturation x2 -> ++red and blue x1-> ++green and blue x1-> --color saturation x2-> ++red and blue x1 -> ++green and blue x1-> ++contrast x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x3-> ++color saturation x2-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1		

Table 80. [54 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x1-> ++contrast x2-> ++color saturation x5		
		
-> ++brightness x5-> ++contrast x4-> ++color saturation x7		
		
-> ++brightness x3-> ++contrast x4		

Table 81. [55 / 65] Intermediate action sequence chosen by our agent.

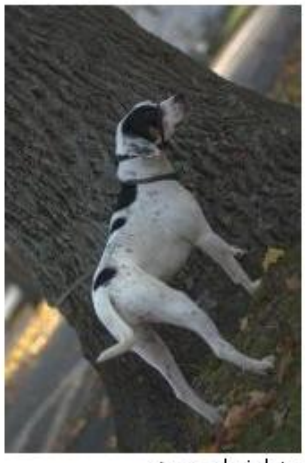
Raw input	Expert C	Ours
		
-> ++brightness x1-> ++contrast x8-> ++color saturation x13		
		
-> ++brightness x4-> ++contrast x11		
		
-> ++green and blue x1-> ++brightness x1-> ++red and blue x1 -> ++green and blue x1-> ++contrast x2		

Table 82. [56 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x1-> ++color saturation x1-> ++brightness x1		
		
-> ++contrast x1-> ++brightness x1-> ++contrast x4 -> ++color saturation x3		
		
-> ++contrast x3-> ++color saturation x12		

Table 83. [57 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x1-> ++brightness x1 -> ++color saturation x3-> ++contrast x1-> ++color saturation x2		
		
-> ++color saturation x1		
		
-> ++brightness x1-> ++contrast x1-> ++brightness x1 -> ++contrast x4-> ++color saturation x4		

Table 84. [58 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x4-> ++color saturation x1 -> --color saturation x1		
		
-> ++contrast x1-> ++color saturation x2		
		
-> ++contrast x1-> ++color saturation x6		

Table 85. [59 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++green and blue x1-> --red and green x1-> --color saturation x1 -> ++red and blue x1-> --color saturation x6-> ++green and blue x1-> --color saturation x2 -> ++red and blue x1-> ++green and blue x1-> --color saturation x1-> ++contrast x1		
		
-> ++brightness x4-> ++contrast x1-> ++brightness x1 -> ++contrast x4		
		
-> ++brightness x4-> ++green and blue x2-> --color saturation x1 -> ++red and blue x1-> ++green and blue x1-> --color saturation x5-> ++green and blue x1 -> --brightness x1-> ++contrast x1		

Table 86. [60 / 65] Intermediate action sequence chosen by our agent.

Raw input	**Expert C**	**Ours**
		

-> --brightness x1-> ++color saturation x4-> --color saturation x1
-> ++color saturation x2-> --color saturation x1-> ++color saturation x1-> --color saturation x1
-> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1
-> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1
-> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1
-> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1
-> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1
-> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1
-> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1
-> ++color saturation x1-> --color saturation x1-> ++color saturation x1-> --color saturation x1
-> ++color saturation x1-> --color saturation x1-> ++color saturation x2-> --color saturation x1
-> ++color saturation x1-> --color saturation x1

-> ++green and blue x1-> --color saturation x49

-> ++contrast x4-> ++green and blue x1-> ++color saturation x3

Table 87. [61 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x1-> ++contrast x13-> ++red and green x1 -> ++contrast x2		
		
-> ++brightness x8-> ++contrast x1-> ++red and green x1 -> ++brightness x1-> ++color saturation x1		
		
	-> ++brightness x6	

Table 88. [62 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x6-> ++red and blue x1 -> ++contrast x5		
		
-> ++brightness x4-> ++contrast x1-> ++brightness x1 -> ++contrast x4-> ++color saturation x1-> ++brightness x1		
		
-> ++brightness x1-> ++contrast x6-> ++brightness x1 -> ++color saturation x3		

Table 89. [63 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x1-> ++contrast x1-> ++color saturation x1		
		
-> ++contrast x1-> ++brightness x1-> ++color saturation x1 -> ++brightness x1-> ++color saturation x1		
		
-> ++brightness x2-> ++contrast x5		

Table 90. [64 / 65] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x7-> ++green and blue x1		
		
-> ++brightness x4-> ++contrast x1-> ++brightness x1 -> ++contrast x1-> ++color saturation x1-> ++red and green x1-> ++color saturation x7		

Table 91. [65 / 65] Intermediate action sequence chosen by our agent.

4.3. Experiment result using distort-and-recover scheme (with intermediate actions)

Raw input	Expert C	Ours
		
-> ++brightness x9-> ++contrast x3-> ++green and blue x1		
		
-> ++brightness x2-> ++contrast x1-> ++red and green x1 -> ++contrast x4		
		
-> --brightness x2-> ++contrast x2-> --brightness x1 -> ++contrast x1-> ++color saturation x3		
		
-> ++brightness x3-> ++contrast x2-> ++brightness x1 -> ++contrast x1		
		
-> ++contrast x3-> --red and green x1-> ++contrast x2 -> ++green and blue x1-> ++contrast x2		

Table 92. [1 / 64] Intermediate action sequence chosen by our agent.

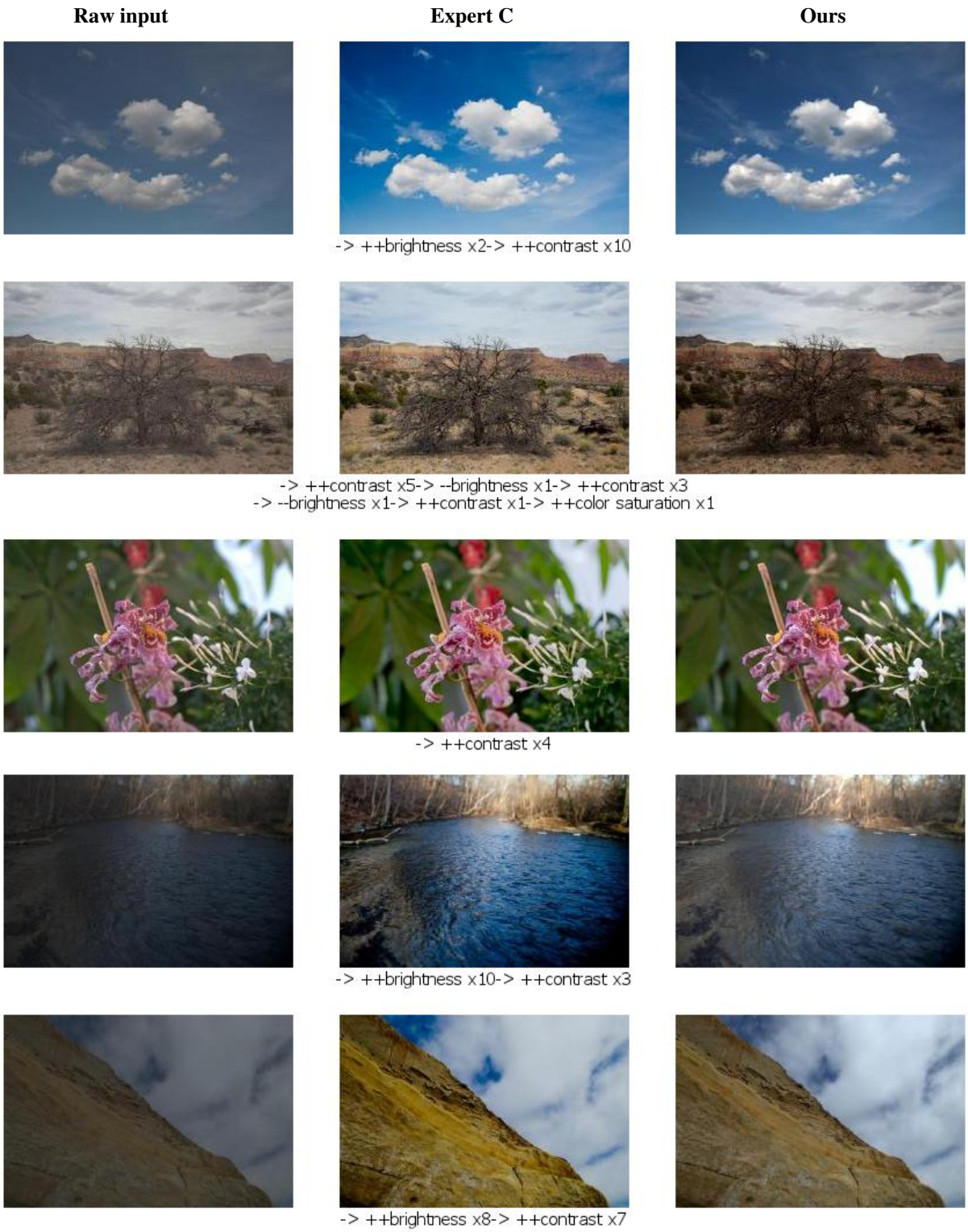


Table 93. [2 / 64] Intermediate action sequence chosen by our agent.

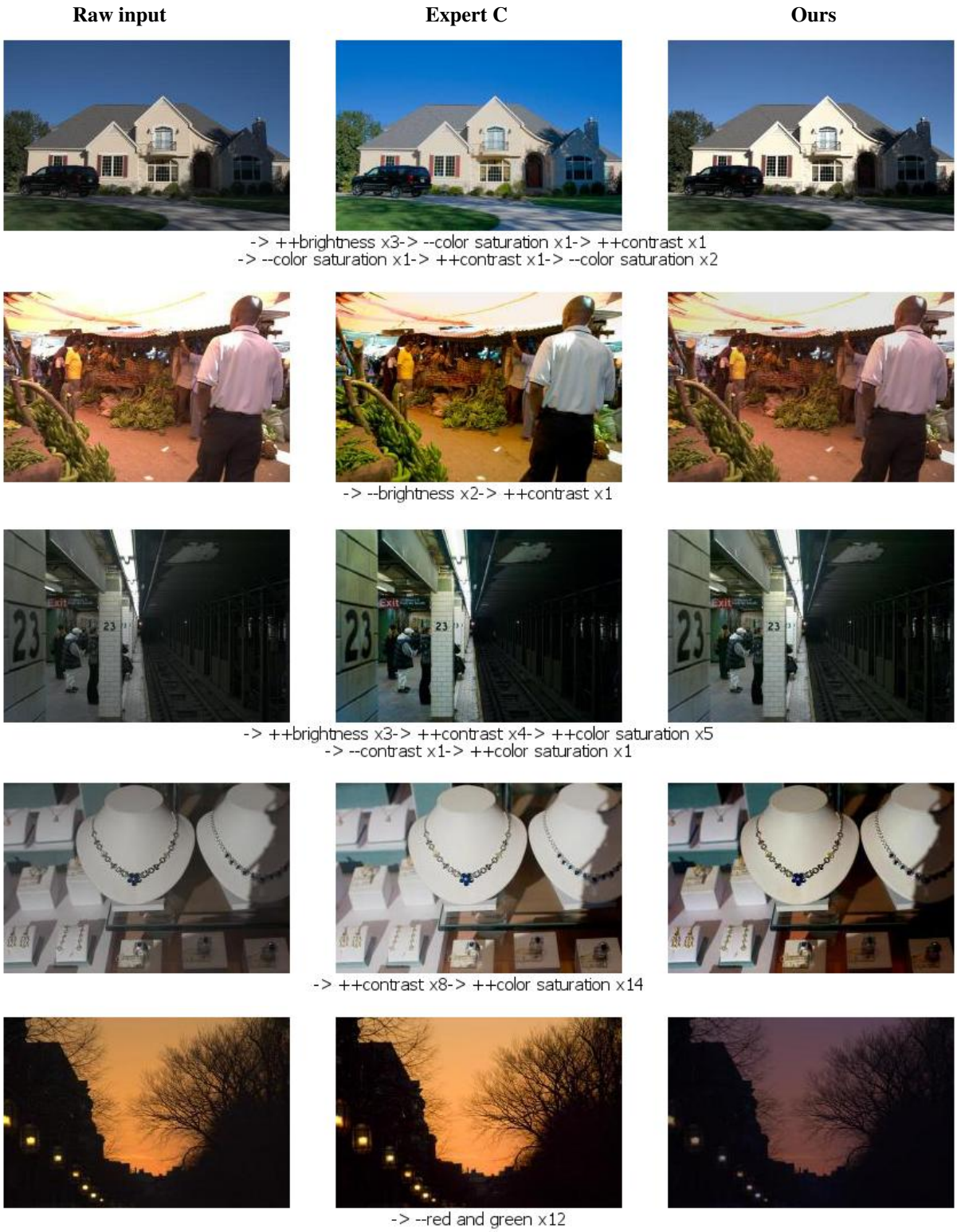


Table 94. [3 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x5-> ++contrast x3-> ++green and blue x1		
		
-> ++brightness x3-> ++green and blue x2-> ++contrast x1 -> --red and green x1-> ++contrast x2-> ++green and blue x1-> ++contrast x2 -> ++red and blue x1-> ++green and blue x1		
		
-> ++brightness x2-> ++contrast x9-> ++color saturation x1 -> --color saturation x2		
		
-> ++brightness x1-> ++contrast x6		
		
-> ++contrast x4-> --brightness x1-> ++contrast x2		

Table 95. [4 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x6-> ++contrast x11		
		
-> ++brightness x5-> ++green and blue x1-> ++contrast x3		
		
-> ++brightness x5-> ++contrast x2-> ++red and blue x1 -> ++contrast x5-> --brightness x1-> ++contrast x2		
		
-> ++brightness x2-> ++red and green x1-> ++contrast x2 -> ++red and green x1-> ++contrast x4-> ++color saturation x2		
		
-> ++brightness x4-> ++contrast x6-> --color saturation x1 -> ++contrast x1-> --color saturation x2		

Table 96. [5 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++contrast x5	
		
	-> ++contrast x7	
		
	-> ++brightness x7-> ++contrast x2-> ++color saturation x1	
		
	-> ++contrast x5-> ++color saturation x7	
		
	-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x7-> --brightness x1-> ++contrast x4-> --brightness x1 -> ++contrast x3	

Table 97. [6 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++brightness x2-> ++contrast x4	
		
	-> --red and green x1-> ++green and blue x1-> ++contrast x2 -> --red and green x1-> ++green and blue x1-> ++contrast x3-> ++red and blue x1 -> --red and green x1-> ++green and blue x1-> ++contrast x2	
		
	-> ++brightness x2-> ++contrast x3	
		
	-> ++brightness x1-> ++contrast x8-> --red and green x1 -> ++brightness x1-> ++contrast x2	
		
	-> ++brightness x1-> ++contrast x13	

Table 98. [7 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> --red and green x1-> --brightness x1-> ++contrast x4 -> --brightness x1-> ++contrast x1		
		
-> ++brightness x4-> ++contrast x5-> ++color saturation x2		
		
-> ++brightness x6-> ++contrast x7-> ++green and blue x1		
		
	-> ++brightness x2-> ++contrast x9	
		
	-> --red and green x1-> ++contrast x2	

Table 99. [8 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++brightness x9-> ++contrast x6	
		
	-> ++brightness x2-> ++contrast x5	
		
	-> ++contrast x2-> ++brightness x1-> ++contrast x1 -> ++green and blue x1-> ++contrast x2-> ++red and blue x1-> ++green and blue x1 -> ++color saturation x2	
		
	-> ++brightness x7-> ++contrast x5-> ++brightness x1 -> ++contrast x3-> ++color saturation x2-> ++red and green x1-> --color saturation x1	
		
	-> ++brightness x7-> ++contrast x7-> ++color saturation x3	

Table 100. [9 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x5-> --red and green x1-> ++brightness x1 -> --brightness x1-> ++contrast x1-> --brightness x1-> ++contrast x2 -> --brightness x1-> ++contrast x1-> ++green and blue x1-> ++brightness x1 -> ++color saturation x1		
		
-> ++brightness x1-> ++contrast x4		
		
-> ++brightness x5-> ++contrast x10		
		
-> ++brightness x1-> ++red and blue x1-> ++brightness x1 -> ++green and blue x1-> ++contrast x1		
		
-> ++brightness x1-> ++contrast x5-> --red and green x1 -> ++contrast x4		

Table 101. [10 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x8-> --brightness x1 -> ++contrast x4-> --brightness x1-> ++contrast x1-> ++color saturation x3 -> ++contrast x1		
		
-> --brightness x1-> ++contrast x4-> --brightness x1 -> ++contrast x1-> --brightness x1-> ++contrast x2-> --brightness x2 -> ++contrast x2-> --brightness x1-> ++contrast x1-> ++color saturation x1		
		
-> ++brightness x2-> ++contrast x1		
		
-> ++contrast x6-> ++color saturation x1		
		
-> ++green and blue x1-> ++contrast x2-> ++green and blue x1 -> --red and green x1-> ++contrast x1		

Table 102. [11 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x6-> ++red and green x1-> ++contrast x8		
		
-> ++brightness x6-> ++red and green x2		
		
-> ++brightness x1-> ++contrast x4-> ++brightness x1 -> ++contrast x1-> ++brightness x1-> ++contrast x2		
		
-> --brightness x2-> ++contrast x2-> --brightness x1 -> ++contrast x2		
		
-> --red and green x2-> ++green and blue x1-> --red and green x1 -> ++green and blue x1-> ++contrast x1-> --red and green x1-> ++contrast x1 -> ++green and blue x1-> ++contrast x1		

Table 103. [12 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++brightness x5-> ++contrast x1	
		
	-> ++brightness x3-> ++contrast x3-> ++brightness x1 -> ++contrast x3-> --brightness x1-> ++contrast x1-> ++red and green x1	
		
	-> ++brightness x1-> ++contrast x3	
		
	-> ++brightness x1-> ++contrast x5-> ++brightness x1 -> ++contrast x2-> ++color saturation x3	
		
	-> --red and green x1-> ++green and blue x1-> --red and green x1 -> ++green and blue x1-> ++contrast x1-> --red and green x1-> ++green and blue x1 -> ++contrast x1-> --red and green x1-> ++green and blue x1-> ++contrast x1 -> ++green and blue x1-> ++red and blue x1-> --color saturation x3	

Table 104. [13 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> --brightness x1-> ++contrast x2-> --brightness x1 -> ++contrast x4		
		
-> ++contrast x2-> ++red and blue x1-> ++contrast x1 -> ++green and blue x1-> ++contrast x2		
		
-> ++brightness x3-> ++red and green x1-> ++contrast x2		
		
-> ++brightness x1-> ++contrast x2-> ++red and green x1 -> ++contrast x1		
		
-> ++brightness x3-> ++contrast x6		

Table 105. [14 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x3-> ++red and green x1-> ++contrast x4		
		
-> ++brightness x2-> ++contrast x7		
		
-> ++green and blue x2-> ++brightness x1-> ++green and blue x1 -> ++red and blue x1-> ++green and blue x1-> ++red and blue x1-> ++green and blue x1 -> ++color saturation x2		
		
-> ++brightness x7-> ++contrast x3-> ++color saturation x10 -> ++green and blue x1-> --contrast x1		
		
-> ++brightness x1-> ++contrast x6-> ++brightness x1 -> ++contrast x1-> ++color saturation x2-> ++brightness x1		

Table 106. [15 / 64] Intermediate action sequence chosen by our agent.

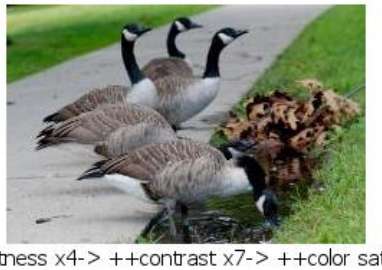
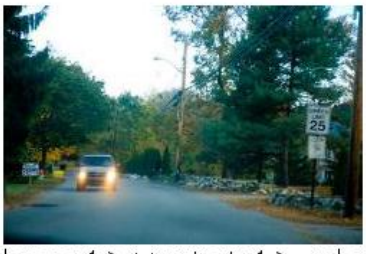
Raw input	Expert C	Ours
		
-> ++brightness x7-> ++green and blue x3-> ++contrast x1 -> --color saturation x1-> ++contrast x1		
		
-> ++brightness x8-> ++contrast x1		
		
-> ++brightness x4-> ++contrast x7-> ++color saturation x1		
		
-> ++brightness x7-> ++contrast x1		
		
-> --red and green x1-> ++contrast x1-> --red and green x1 -> ++contrast x2-> --brightness x1-> ++contrast x2		

Table 107. [16 / 64] Intermediate action sequence chosen by our agent.

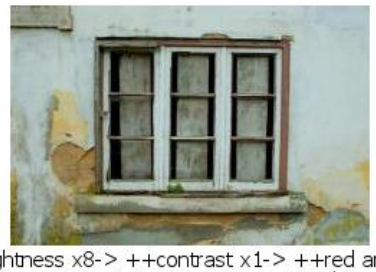
Raw input	Expert C	Ours
		
-> ++brightness x7-> ++green and blue x2-> --color saturation x1 -> ++green and blue x1-> --color saturation x1-> ++green and blue x1-> --color saturation x1		
		
-> ++brightness x8-> ++contrast x1-> ++red and blue x1 -> ++brightness x1-> ++contrast x3-> ++color saturation x1		
		
-> ++brightness x1-> ++contrast x5		
		
-> ++contrast x1-> --brightness x1-> ++contrast x2 -> --brightness x1-> ++contrast x2		
		
-> --brightness x1-> --color saturation x3		

Table 108. [17 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x3-> ++contrast x4-> ++red and blue x1 -> ++green and blue x1-> ++color saturation x1-> ++red and blue x1-> ++green and blue x1		
		
-> ++brightness x2-> ++green and blue x2-> ++contrast x4 -> ++red and blue x1-> ++green and blue x1-> --red and green x1-> ++green and blue x1 -> --red and green x1-> ++green and blue x1-> ++contrast x2		
		
-> ++contrast x6-> ++brightness x1-> ++contrast x3		
		
-> ++brightness x6-> ++contrast x9-> --brightness x1 -> ++contrast x3-> ++color saturation x3		
		
-> --brightness x1-> ++contrast x2		

Table 109. [18 / 64] Intermediate action sequence chosen by our agent.

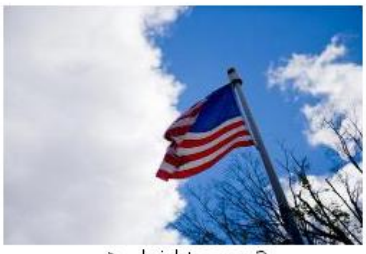
Raw input	Expert C	Ours
		
-> ++contrast x1-> --brightness x1-> ++contrast x4 -> --brightness x1-> ++contrast x1		
		
-> --brightness x3		
		
-> ++brightness x5-> ++contrast x7		
		
-> ++brightness x4-> ++contrast x2-> ++brightness x1		
		
-> ++contrast x2-> ++brightness x1-> ++contrast x4 -> ++color saturation x2-> ++contrast x2-> ++color saturation x4		

Table 110. [19 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x3		
		
-> --brightness x2-> ++contrast x2-> --brightness x1 -> ++contrast x3-> --brightness x1-> ++contrast x3-> --brightness x1		
		
-> ++brightness x1-> ++contrast x5-> ++color saturation x4		
		
-> ++contrast x5-> --red and green x1-> ++green and blue x1 -> ++contrast x1-> ++green and blue x1		
		
-> ++contrast x3		

Table 111. [20 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x8-> ++contrast x2		
		
-> ++contrast x1-> --red and green x1-> ++contrast x1 -> ++green and blue x1-> ++contrast x1-> --brightness x1-> ++contrast x1 -> --color saturation x1-> ++contrast x1-> --color saturation x1		
		
-> --brightness x1-> ++contrast x1-> --brightness x1 -> ++contrast x3-> --brightness x1-> ++contrast x1-> --brightness x1 -> ++contrast x2		
		
		
-> ++brightness x2-> ++contrast x3-> ++green and blue x1 -> ++red and blue x1-> ++green and blue x1-> ++red and blue x1-> ++green and blue x1		

Table 112. [21 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x4-> ++contrast x1-> ++brightness x2 -> ++contrast x2-> ++brightness x1-> ++contrast x1-> ++red and blue x1 -> ++green and blue x1-> --red and green x1-> ++green and blue x1-> ++contrast x1 -> ++green and blue x1-> --red and green x1-> ++brightness x1-> ++green and blue x1		
		
-> ++contrast x4		
		
-> ++brightness x4-> ++contrast x1-> ++red and blue x1 -> ++brightness x1-> ++contrast x3		
		
-> ++green and blue x2-> --color saturation x1-> ++red and green x4 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> ++red and green x1-> --color saturation x1-> ++red and green x1		
		
-> ++contrast x4-> ++color saturation x2		

Table 113. [22 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
	 -> ++brightness x5-> ++contrast x10	
	 -> ++brightness x6-> ++contrast x2	
	 -> ++contrast x2	
	 -> ++brightness x5-> ++green and blue x2-> --color saturation x7	
	 -> ++brightness x1-> ++contrast x2-> ++brightness x1 -> ++contrast x3-> ++green and blue x1-> ++color saturation x2-> ++contrast x1 -> ++color saturation x2	

Table 114. [23 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++brightness x6-> ++contrast x4	
		
	-> --brightness x2-> ++contrast x2-> --brightness x1 -> ++contrast x2-> --brightness x1-> ++color saturation x5	
		
	-> ++contrast x12	
		
	-> --red and green x1-> ++green and blue x1-> --contrast x1	
		
	-> ++brightness x3-> ++contrast x8-> ++red and blue x1 -> ++brightness x1-> ++red and blue x1-> ++color saturation x6	

Table 115. [24 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x3-> ++green and blue x1-> ++contrast x2 -> ++green and blue x1-> ++contrast x2-> ++green and blue x1-> --red and green x1 -> ++contrast x1-> ++green and blue x1-> ++contrast x2-> ++green and blue x1 -> ++contrast x1		
		
-> --red and green x1-> ++green and blue x1-> ++contrast x9		
		
-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x3-> ++red and green x1-> ++contrast x1		
		
-> --brightness x2-> ++contrast x2-> --brightness x1 -> ++contrast x4		
		
-> ++contrast x5-> ++brightness x1-> ++contrast x1 -> ++color saturation x1		

Table 116. [25 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x7-> ++red and blue x1-> ++color saturation x3		
		
-> ++brightness x9-> ++contrast x6-> --brightness x1 -> ++contrast x4-> --brightness x1-> ++contrast x3-> --brightness x1 -> ++contrast x3		
		
-> ++brightness x3-> ++contrast x2-> ++brightness x1 -> ++contrast x4		
		
-> ++contrast x3-> --brightness x1-> ++contrast x1 -> --brightness x1-> ++contrast x2-> ++color saturation x3		
		
-> ++brightness x2-> ++contrast x2-> ++color saturation x2		

Table 117. [26 / 64] Intermediate action sequence chosen by our agent.

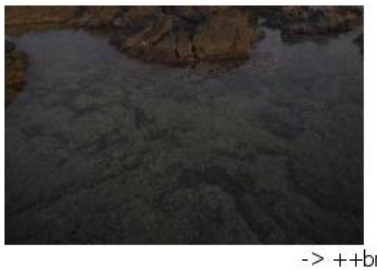
Raw input	Expert C	Ours
		
-> ++contrast x2-> --brightness x1-> ++contrast x2 -> --red and green x1-> ++green and blue x1-> ++contrast x1		
		
-> ++brightness x12-> ++green and blue x1-> ++contrast x6		
		
-> --brightness x2-> ++contrast x1-> --brightness x1 -> ++contrast x1		
		
-> ++brightness x2-> ++contrast x14		
		
-> ++brightness x2-> ++contrast x4		

Table 118. [27 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> --brightness x2		
		
-> ++contrast x1-> --brightness x1-> ++contrast x3 -> --brightness x1-> ++contrast x4-> --brightness x1-> ++contrast x1		
		
-> ++contrast x4-> ++color saturation x4		
		
-> ++brightness x5-> ++contrast x5-> ++color saturation x5		
		
-> ++contrast x8-> ++brightness x2-> ++contrast x7		

Table 119. [28 / 64] Intermediate action sequence chosen by our agent.

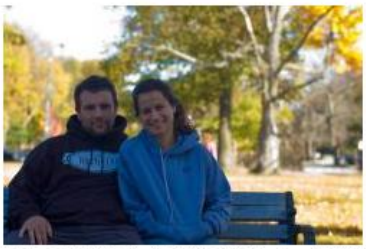
Raw input	Expert C	Ours
		
-> --brightness x2-> ++contrast x2-> --brightness x1		
		
-> ++contrast x3-> ++green and blue x2-> ++contrast x1 -> ++green and blue x1-> ++color saturation x4		
		
-> ++brightness x1-> ++contrast x7		
		
-> --brightness x2-> ++contrast x2		
		
-> ++brightness x10-> ++contrast x3-> ++color saturation x6		

Table 120. [29 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
	-> ++contrast x3-> ++color saturation x1	
		
	-> ++brightness x3-> ++contrast x4-> ++red and blue x1 -> ++contrast x1-> ++color saturation x1	
		
	-> ++contrast x6	
		
	-> --red and green x3-> ++contrast x3-> ++green and blue x1 -> ++contrast x1-> --brightness x1-> ++contrast x2	

Table 121. [30 / 64] Intermediate action sequence chosen by our agent.

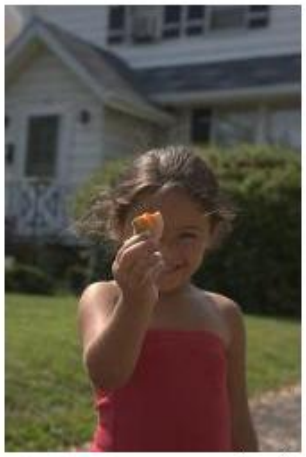
Raw input	Expert C	Ours
		
-> ++green and blue x1-> ++contrast x4-> ++green and blue x1 -> ++contrast x2-> --red and green x1-> ++contrast x1-> --red and green x1 -> ++contrast x2-> --red and green x1-> ++contrast x2		
		
-> ++brightness x4-> ++contrast x7-> --color saturation x1		
		
-> ++brightness x7-> ++contrast x2		

Table 122. [31 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x6-> ++color saturation x7-> --red and green x1 -> ++brightness x1-> ++color saturation x2		
		
-> ++brightness x6-> ++contrast x2-> --brightness x2 -> ++contrast x1		
		
-> ++contrast x10		

Table 123. [32 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x3-> ++contrast x5		
		
-> ++brightness x1-> ++contrast x1-> ++brightness x1 -> ++contrast x1-> ++brightness x1-> ++contrast x1-> ++red and blue x2 -> ++contrast x2		
		
-> ++brightness x7-> ++green and blue x2		

Table 124. [33 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x6-> ++green and blue x1-> ++contrast x2 -> ++green and blue x1-> ++red and blue x1-> ++green and blue x1-> ++red and blue x1 -> ++green and blue x1-> ++color saturation x2		
		
-> ++brightness x3-> ++contrast x5		
		
-> ++brightness x2-> ++contrast x1-> ++green and blue x1 -> ++contrast x4-> ++green and blue x1-> --red and green x1-> ++brightness x1 -> --red and green x1-> ++brightness x1		

Table 125. [34 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x1-> --red and green x1-> ++contrast x2 -> --red and green x1-> ++green and blue x1-> ++color saturation x5-> ++green and blue x1 -> ++red and blue x1		
		
-> ++brightness x10-> ++contrast x3-> ++color saturation x1		
		
-> ++brightness x6-> ++green and blue x2-> --red and green x1 -> ++brightness x1-> ++green and blue x1-> --red and green x1-> ++brightness x1 -> ++red and blue x1-> ++brightness x1-> ++green and blue x1-> ++contrast x2 -> --red and green x1-> ++contrast x6		

Table 126. [35 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x1-> ++contrast x3		
		
-> ++contrast x3-> ++green and blue x1		
		
-> ++brightness x4-> ++contrast x6-> ++red and blue x1 -> ++contrast x1-> ++red and blue x1		

Table 127. [36 / 64] Intermediate action sequence chosen by our agent.

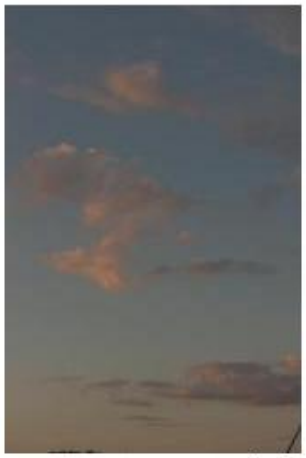
Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x2-> ++green and blue x1 -> --red and green x1-> ++contrast x3-> ++green and blue x1-> ++red and blue x1 -> ++color saturation x7		
		
-> ++brightness x2-> ++contrast x1-> ++brightness x1 -> --red and green x1-> ++contrast x1-> ++brightness x1-> --brightness x1 -> --color saturation x1		
		
-> ++brightness x7-> ++contrast x6-> --red and green x1 -> ++contrast x4		

Table 128. [37 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x4-> ++contrast x7		
		
-> ++brightness x1-> ++contrast x7-> ++red and blue x1 -> ++green and blue x1-> ++contrast x1		
		
-> ++brightness x5-> ++contrast x9-> ++color saturation x1		

Table 129. [38 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x2-> ++brightness x1 -> ++contrast x7-> ++color saturation x1		
		
-> ++brightness x1-> ++contrast x4-> ++color saturation x2		
		
-> --brightness x1-> ++contrast x1-> --brightness x1 -> ++contrast x1		

Table 130. [39 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> --brightness x2-> ++contrast x2-> --brightness x1 -> ++contrast x2		
		
-> --brightness x2-> ++contrast x1-> --red and green x1 -> ++contrast x3-> --brightness x1-> ++contrast x2		
		
-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x1-> ++brightness x1-> ++color saturation x1		

Table 131. [40 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x6-> ++color saturation x4		
		
-> --red and green x1-> ++green and blue x2-> ++contrast x1 -> --red and green x1-> ++contrast x3		
		
-> ++brightness x9-> ++red and blue x1-> ++brightness x1		

Table 132. [41 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> --brightness x1-> ++contrast x1-> --brightness x1 -> ++contrast x3-> --brightness x1-> ++contrast x2-> --brightness x1 -> ++contrast x2-> --brightness x1-> ++contrast x2-> --brightness x1		
		
-> ++brightness x2-> ++green and blue x1-> --red and green x1 -> ++brightness x1-> ++red and blue x1-> ++brightness x1-> ++green and blue x1 -> --red and green x1-> ++brightness x1-> ++green and blue x1-> ++red and blue x1 -> ++green and blue x1-> ++contrast x2-> ++color saturation x4		
		
-> ++brightness x12-> ++contrast x6-> ++color saturation x1		

Table 133. [42 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x6-> ++contrast x5		
		
-> ++brightness x3-> ++contrast x1-> ++brightness x1 -> ++contrast x1-> ++brightness x1-> ++contrast x1-> ++color saturation x1 -> --red and green x1-> ++brightness x1-> ++color saturation x1		
		
-> ++brightness x10-> ++contrast x2-> ++color saturation x6		

Table 134. [43 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x5-> ++contrast x3-> ++color saturation x6		
		
-> ++contrast x1-> --red and green x1-> ++contrast x1 -> --color saturation x1		
		
-> --brightness x1-> ++contrast x1-> --brightness x1 -> ++contrast x1		

Table 135. [44 / 64] Intermediate action sequence chosen by our agent.

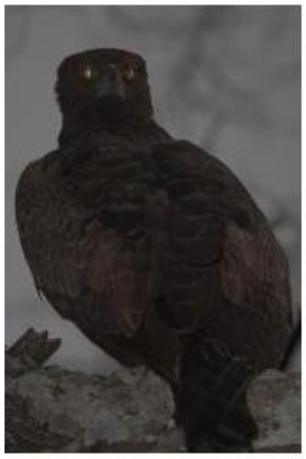
Raw input	Expert C	Ours
		
-> ++brightness x8-> ++contrast x6		
		
-> ++brightness x1-> ++green and blue x1-> ++contrast x1 -> ++red and blue x1-> ++green and blue x1		
		
-> ++brightness x4-> ++contrast x4		

Table 136. [45 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x7-> ++color saturation x4		
		
-> ++contrast x1-> --brightness x1-> ++contrast x2 -> --brightness x1-> ++contrast x1		
		
-> ++brightness x4-> ++contrast x4-> ++green and blue x1 -> --color saturation x1		

Table 137. [46 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x7-> ++color saturation x1		
		
-> --brightness x1-> ++contrast x1		
		
-> ++brightness x1-> ++contrast x9-> ++red and green x1 -> ++color saturation x4		

Table 138. [47 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x2-> --red and green x1-> ++contrast x8 -> --brightness x1-> ++contrast x1-> ++color saturation x1		
		
-> ++contrast x3-> ++color saturation x4		
		
-> ++brightness x3-> ++red and green x1-> ++contrast x5		

Table 139. [48 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x3-> ++contrast x3		
		
-> ++brightness x1-> ++red and green x1-> ++contrast x2 -> ++color saturation x3		
		
-> ++brightness x2-> ++contrast x7-> ++color saturation x1		

Table 140. [49 / 64] Intermediate action sequence chosen by our agent.

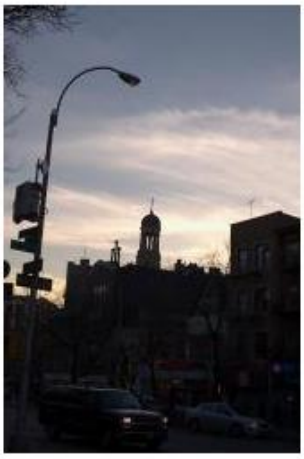
Raw input	Expert C	Ours
		
-> --red and green x1-> ++contrast x1-> ++color saturation x1		
		
-> --brightness x1-> ++contrast x1		
		
-> ++brightness x6-> ++green and blue x1-> ++contrast x2 -> ++red and blue x1-> ++green and blue x1		

Table 141. [50 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x9-> --brightness x1-> ++contrast x2 -> --contrast x1-> ++contrast x1		
		
-> ++brightness x3-> ++contrast x2-> ++brightness x1 -> ++contrast x1-> ++color saturation x3		
		
-> ++contrast x4		

Table 142. [51 / 64] Intermediate action sequence chosen by our agent.

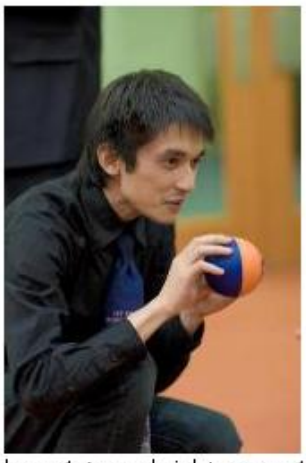
Raw input	Expert C	Ours
		
-> ++brightness x6-> ++green and blue x3-> ++brightness x1 -> ++red and blue x1-> --red and green x1-> ++color saturation x4		
		
-> ++green and blue x1-> ++brightness x1-> ++contrast x2 -> ++green and blue x1-> ++contrast x1-> --red and green x2-> ++contrast x1 -> --red and green x1-> --color saturation x2-> ++green and blue x1-> --color saturation x1 -> ++green and blue x1-> --color saturation x1		
		
-> ++brightness x2-> ++green and blue x2-> ++color saturation x1		

Table 143. [52 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> --red and green x5-> ++green and blue x1-> --red and green x1 -> ++contrast x3-> --color saturation x1-> ++contrast x1-> --color saturation x1 -> ++contrast x1-> --color saturation x2-> ++contrast x1-> --color saturation x1 -> ++contrast x1-> --color saturation x1-> ++contrast x1-> --color saturation x2 -> ++contrast x1-> --color saturation x1-> ++contrast x1-> --color saturation x1 -> ++contrast x1-> --color saturation x1-> ++green and blue x1-> --color saturation x2 -> ++color saturation x1		
		
-> ++brightness x2-> ++contrast x4-> ++color saturation x1		
		
-> ++contrast x8-> ++color saturation x2		

Table 144. [53 / 64] Intermediate action sequence chosen by our agent.

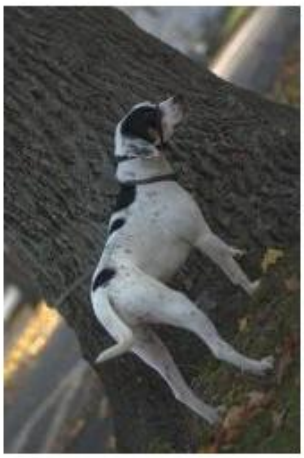
Raw input	Expert C	Ours
		
-> ++brightness x3-> ++contrast x5-> --red and green x1 -> ++contrast x1		
		
-> ++contrast x11-> --brightness x1-> ++contrast x1 -> ++color saturation x1		
		
-> ++brightness x5-> ++contrast x6-> ++red and green x1 -> --brightness x1-> ++contrast x2		

Table 145. [54 / 64] Intermediate action sequence chosen by our agent.

Table 146. [55 / 64] Intermediate action sequence chosen by our agent.

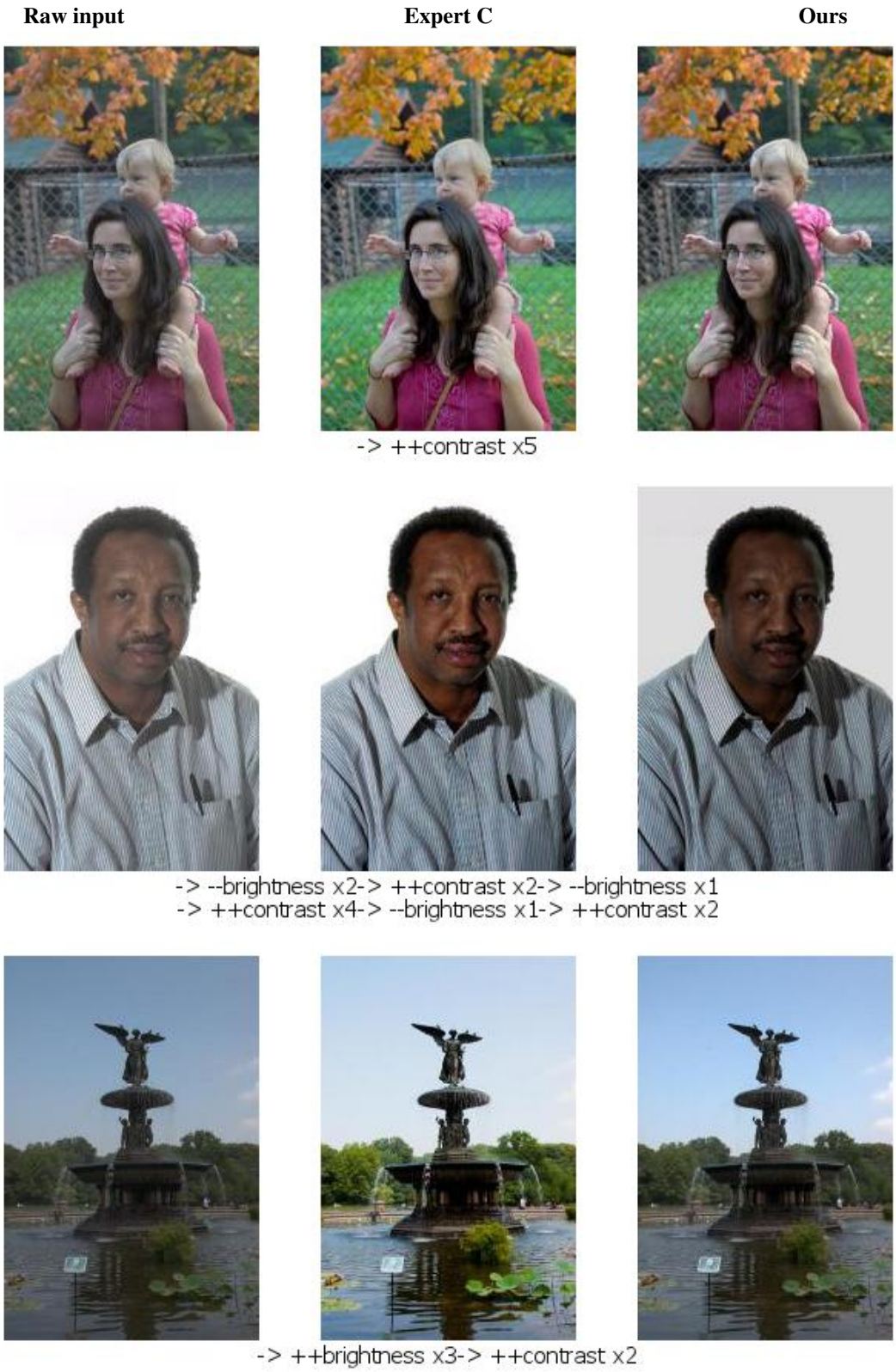


Table 147. [56 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> --brightness x1-> ++contrast x2-> --brightness x1 -> ++contrast x3		
		
-> ++brightness x1-> ++contrast x7		
		
-> ++brightness x1-> ++contrast x5-> ++green and blue x1 -> --brightness x1-> --color saturation x1-> ++contrast x1-> --color saturation x2 -> ++contrast x1-> --color saturation x1		

Table 148. [57 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++contrast x1-> --red and green x1-> ++contrast x1 -> ++green and blue x1-> ++color saturation x1-> ++red and blue x1		
		
-> ++contrast x1		
		
-> ++green and blue x2-> --red and green x1-> ++green and blue x3 -> ++red and blue x1-> ++green and blue x1-> ++red and blue x1-> --red and green x1 -> ++contrast x2		

Table 149. [58 / 64] Intermediate action sequence chosen by our agent.

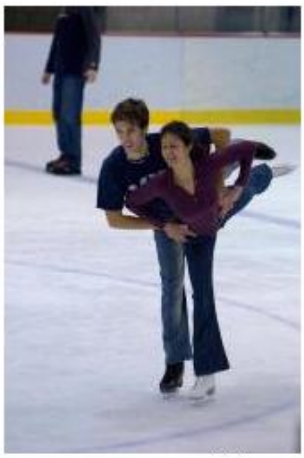
Raw input	Expert C	Ours
		
-> ++brightness x4-> ++contrast x8-> ++color saturation x1		
		
-> ++brightness x2-> ++green and blue x2-> ++contrast x2 -> ++green and blue x1-> ++contrast x2-> --red and green x1-> ++green and blue x1 -> ++red and blue x1-> ++green and blue x1-> ++color saturation x1		
		
-> ++brightness x5-> ++green and blue x2-> ++contrast x1 -> --red and green x1-> ++contrast x1-> --color saturation x1-> ++contrast x1 -> --red and green x1-> ++green and blue x1-> ++contrast x4-> --red and green x1 -> ++contrast x1-> ++green and blue x1-> ++brightness x1-> ++contrast x2 -> ++green and blue x1-> ++color saturation x5-> ++green and blue x1-> ++brightness x1		

Table 150. [59 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x5-> ++contrast x1-> ++red and blue x3		
		
-> ++contrast x3		
		
-> ++brightness x3-> ++contrast x10		

Table 151. [60 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x10-> ++red and green x1		
		
-> ++brightness x4-> ++contrast x4-> ++color saturation x1 -> ++red and green x1		
		
-> --red and green x1-> ++contrast x5-> --red and green x1 -> ++contrast x6		

Table 152. [61 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x5-> ++contrast x7-> ++green and blue x1 -> ++red and blue x1		
		
-> ++contrast x7		
		
-> ++brightness x1-> ++contrast x5-> --brightness x1 -> ++contrast x2		

Table 153. [62 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x2-> ++contrast x2-> ++red and blue x1 -> --color saturation x6		
		
-> ++green and blue x3-> --red and green x1-> ++green and blue x2 -> --red and green x1-> ++contrast x1-> ++green and blue x1-> --color saturation x2 -> ++contrast x1-> --color saturation x1-> ++contrast x1-> --color saturation x2 -> ++contrast x1-> --color saturation x2-> ++contrast x1-> --color saturation x2 -> ++contrast x1-> --color saturation x6-> ++contrast x1-> --color saturation x3 -> ++contrast x1-> --color saturation x2		
		
-> ++contrast x3-> ++brightness x2-> ++contrast x1 -> ++brightness x1-> ++contrast x6		

Table 154. [63 / 64] Intermediate action sequence chosen by our agent.

Raw input	Expert C	Ours
		
-> ++brightness x10-> --color saturation x1-> ++brightness x1 -> --color saturation x2-> ++red and green x1-> --color saturation x4-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1 -> --color saturation x1-> ++color saturation x1-> --color saturation x1-> ++color saturation x1		
		
-> ++brightness x3-> ++contrast x6-> ++red and green x1		

Table 155. [64 / 64] Intermediate action sequence chosen by our agent.

4.4. Experiment result using input-retouched image pairs from MIT5K expert C. (compared with Pix2Pix baseline)

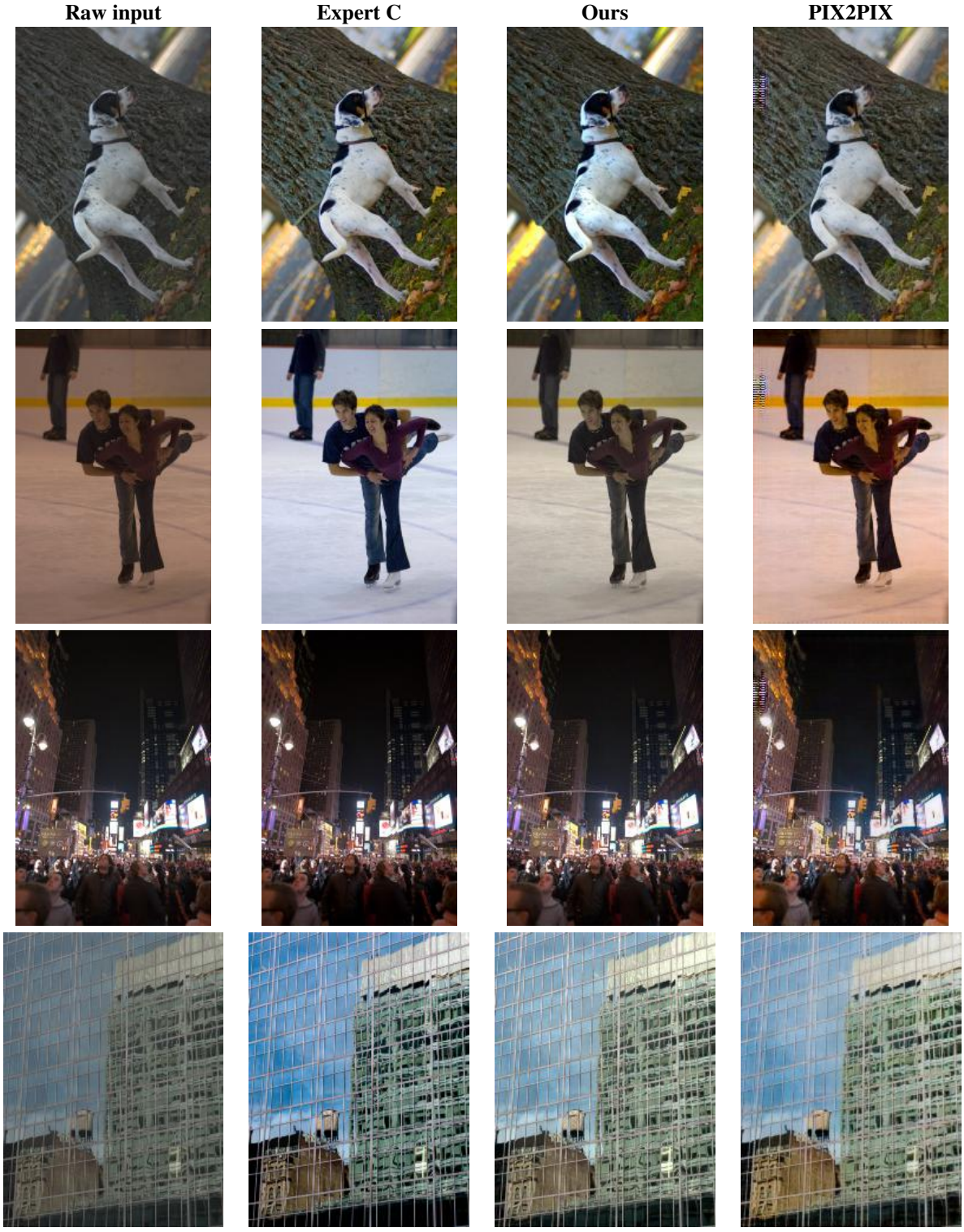


Table 156. [1 / 46] Experiment result using input-retouched image pairs

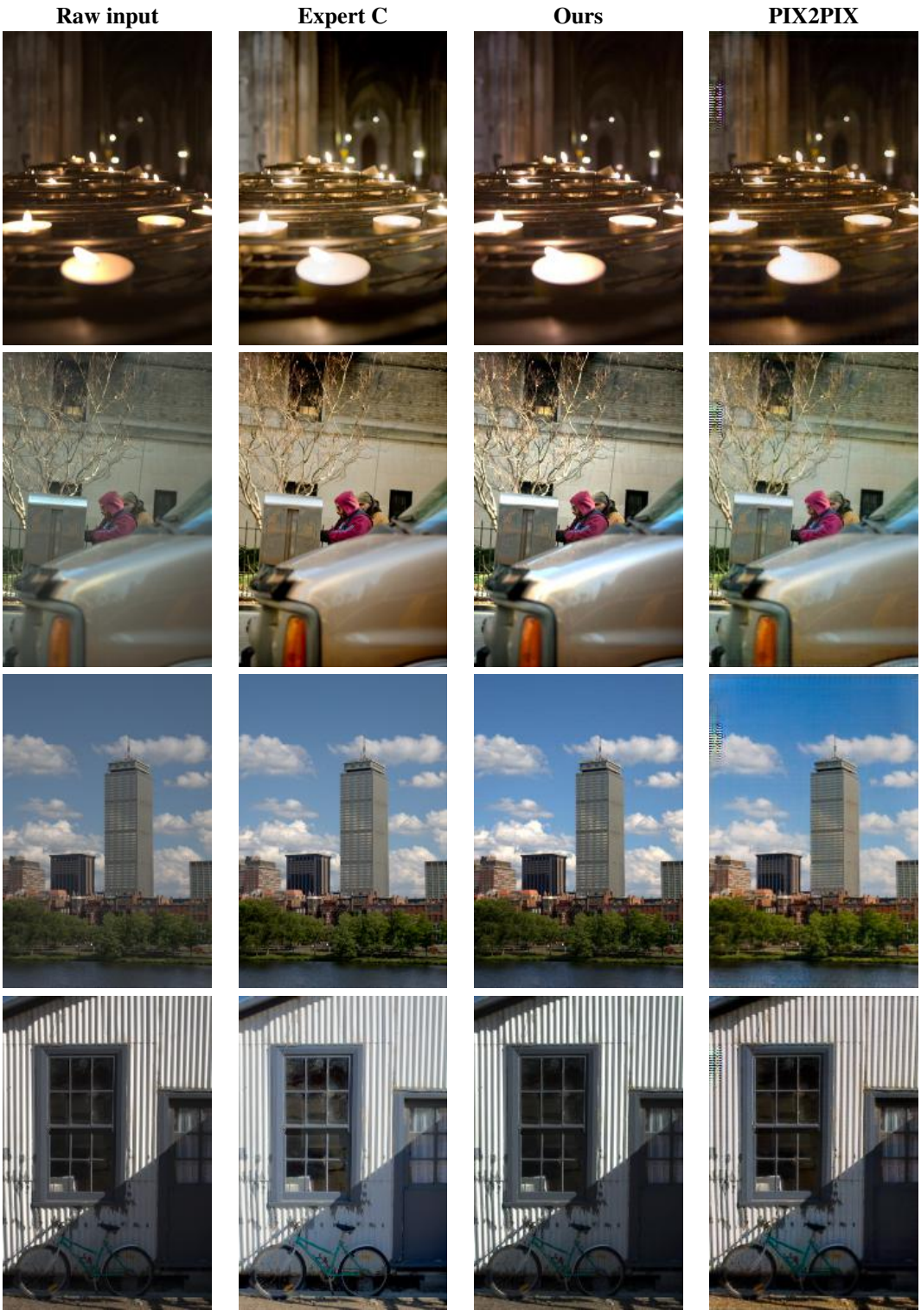


Table 157. [2 / 46] Experiment result using input-retouched image pairs

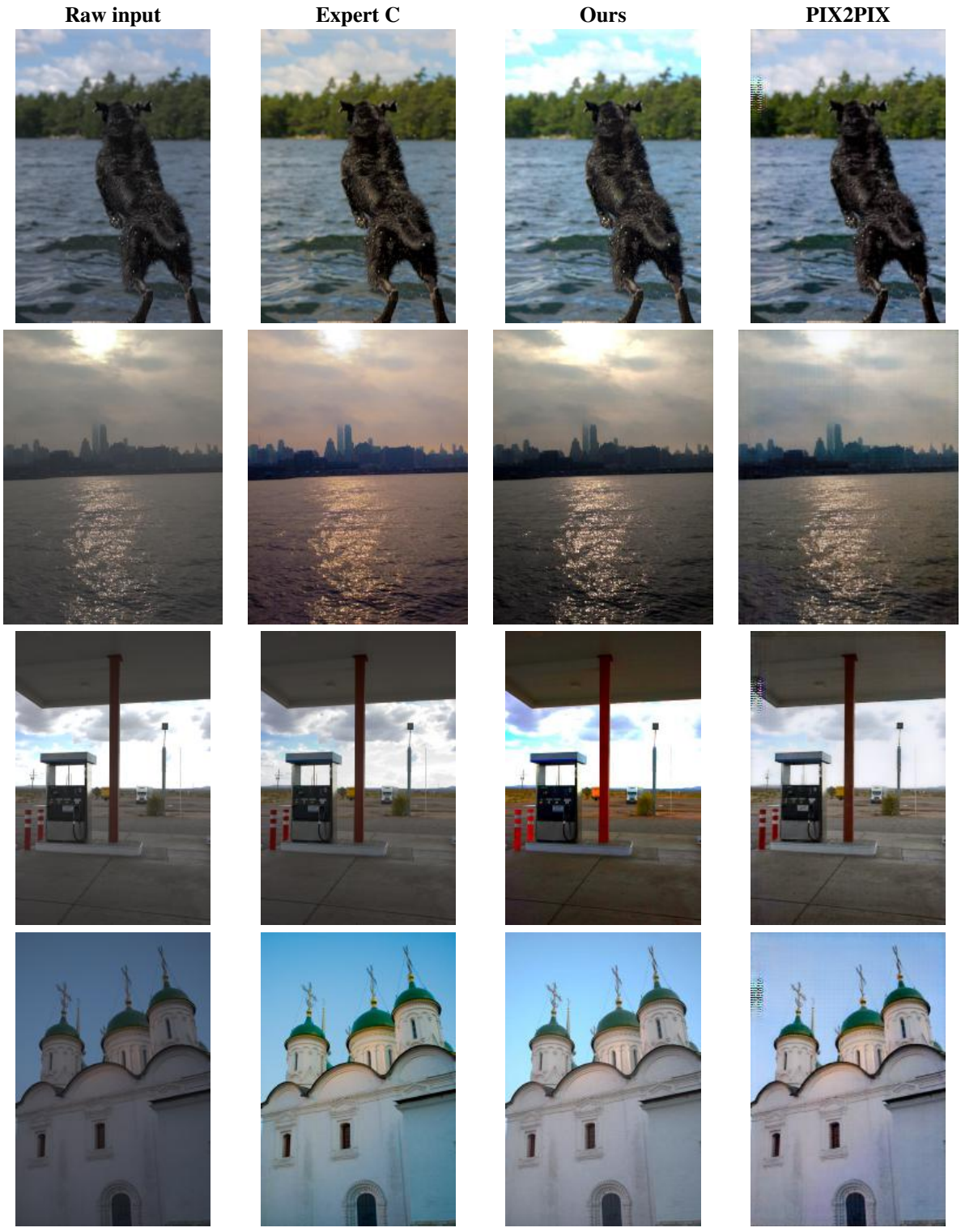


Table 158. [3 / 46] Experiment result using input-retouched image pairs

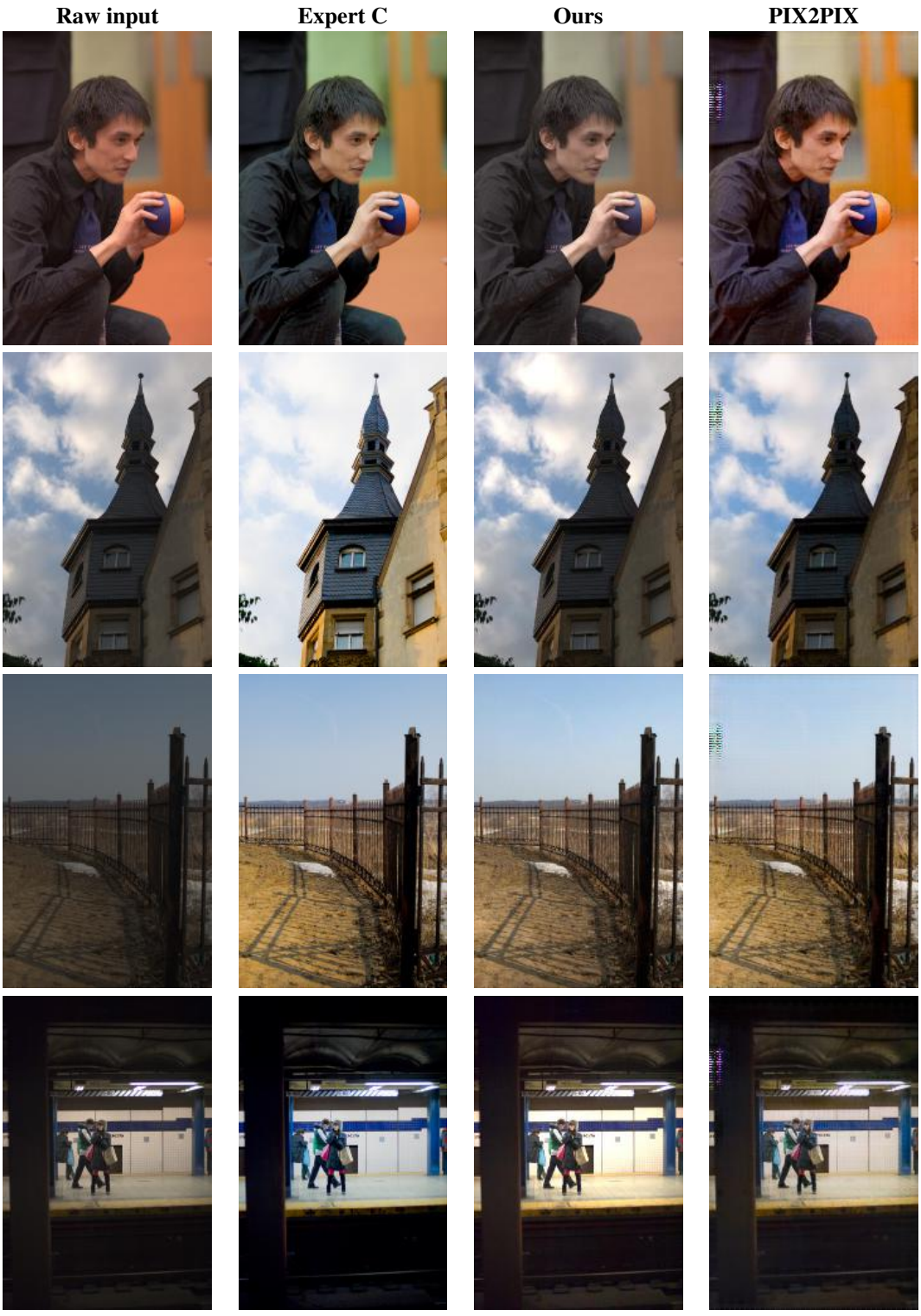


Table 159. [4 / 46] Experiment result using input-retouched image pairs

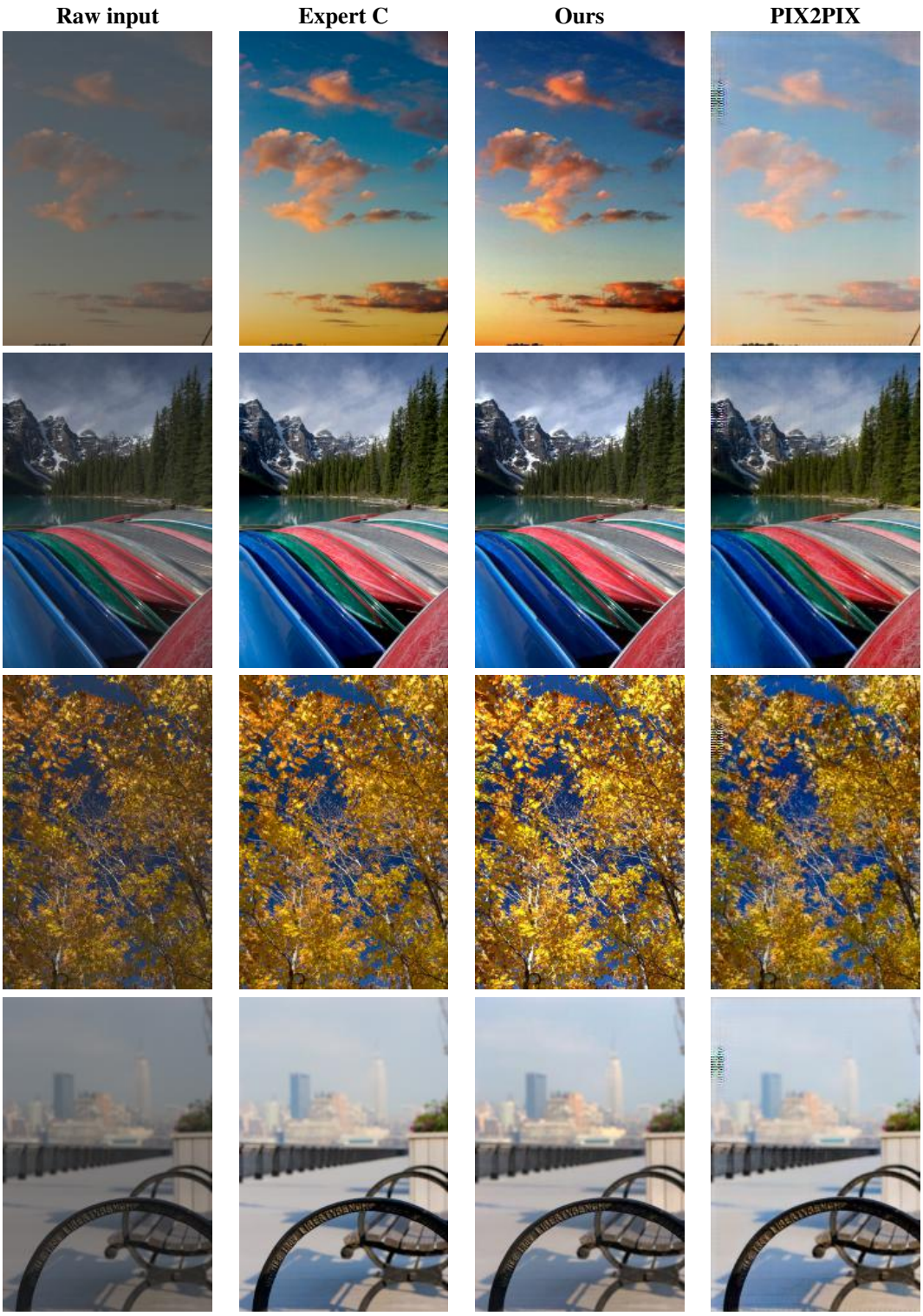


Table 160. [5 / 46] Experiment result using input-retouched image pairs

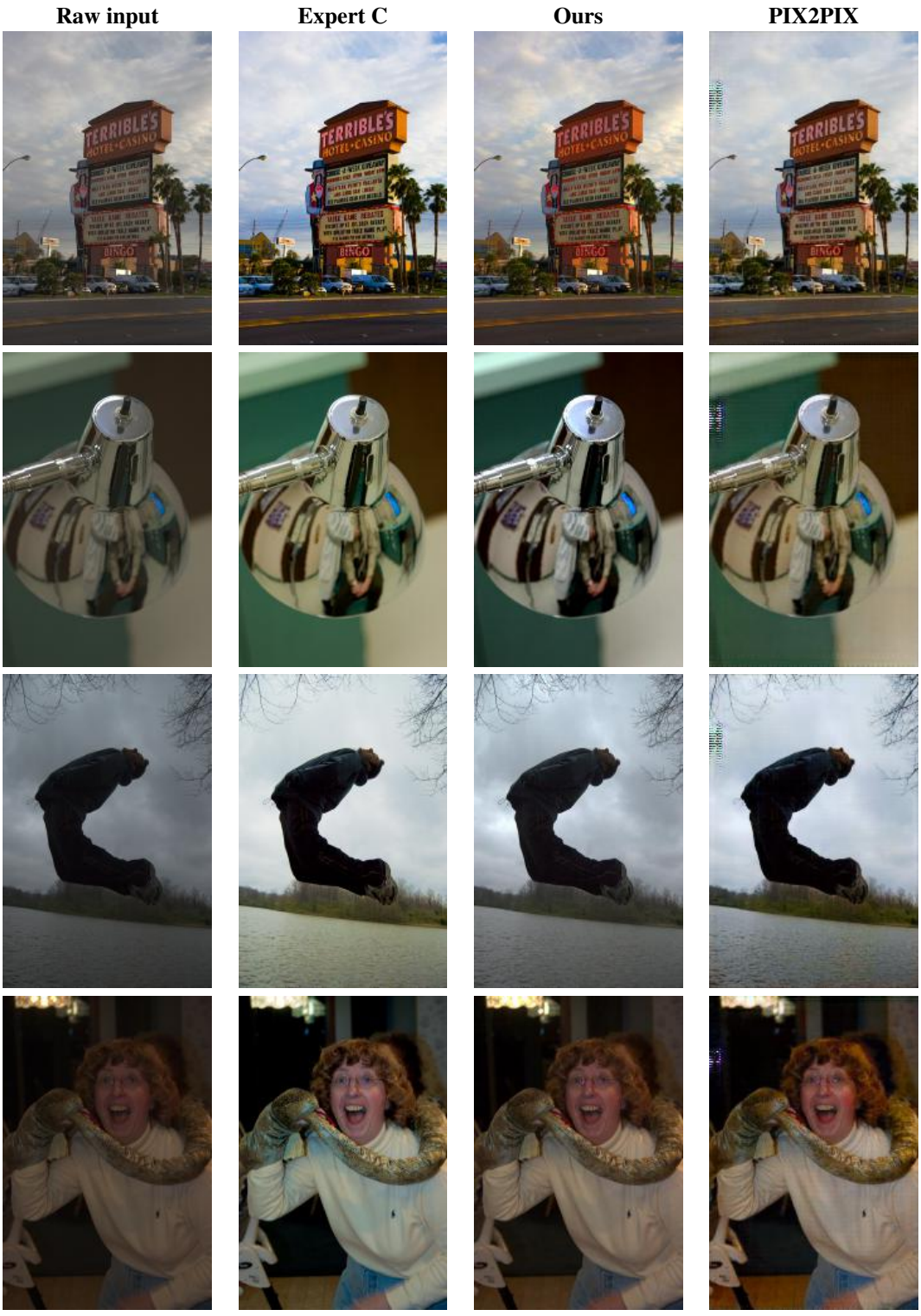


Table 161. [6 / 46] Experiment result using input-retouched image pairs

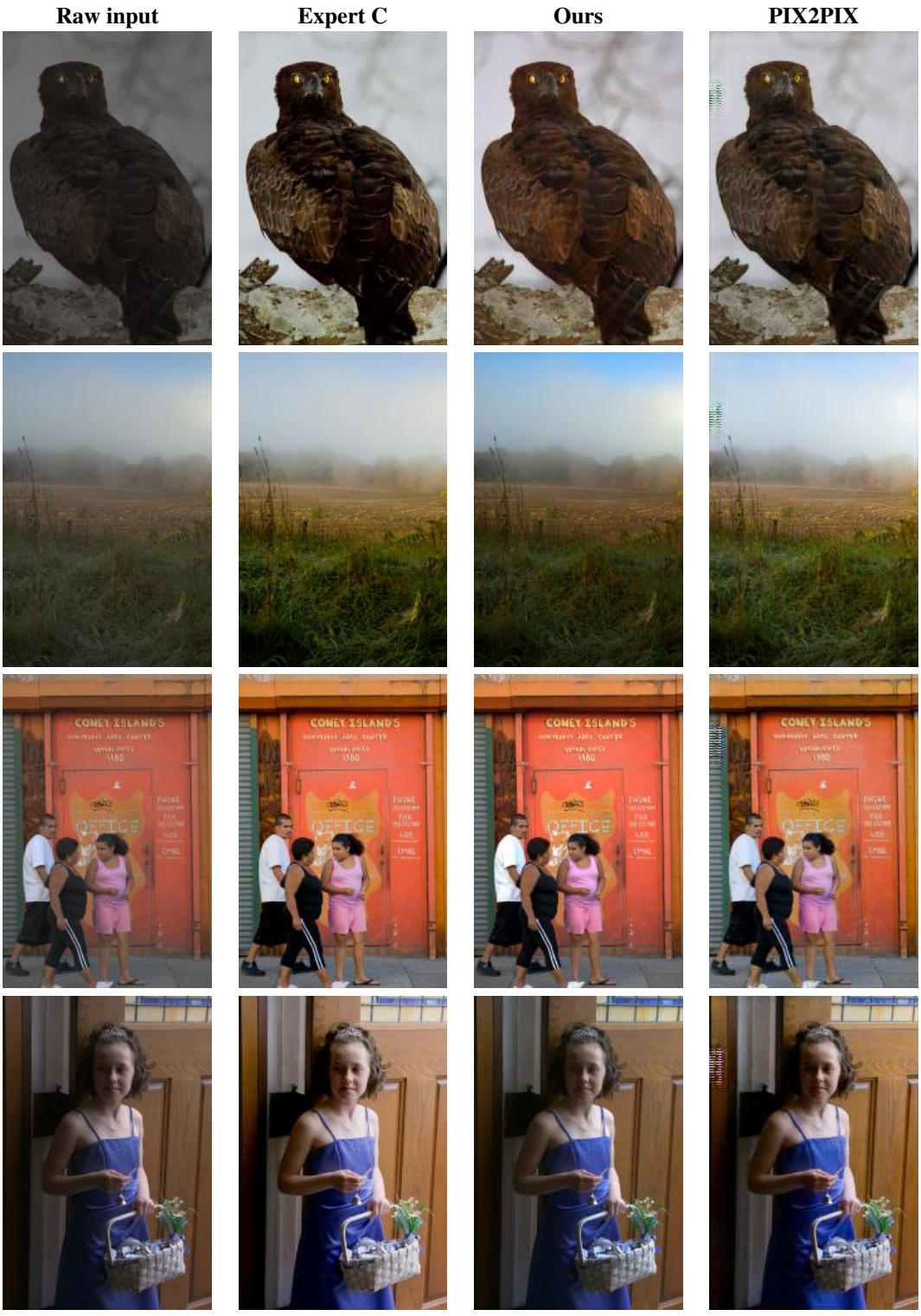


Table 162. [7 / 46] Experiment result using input-retouched image pairs

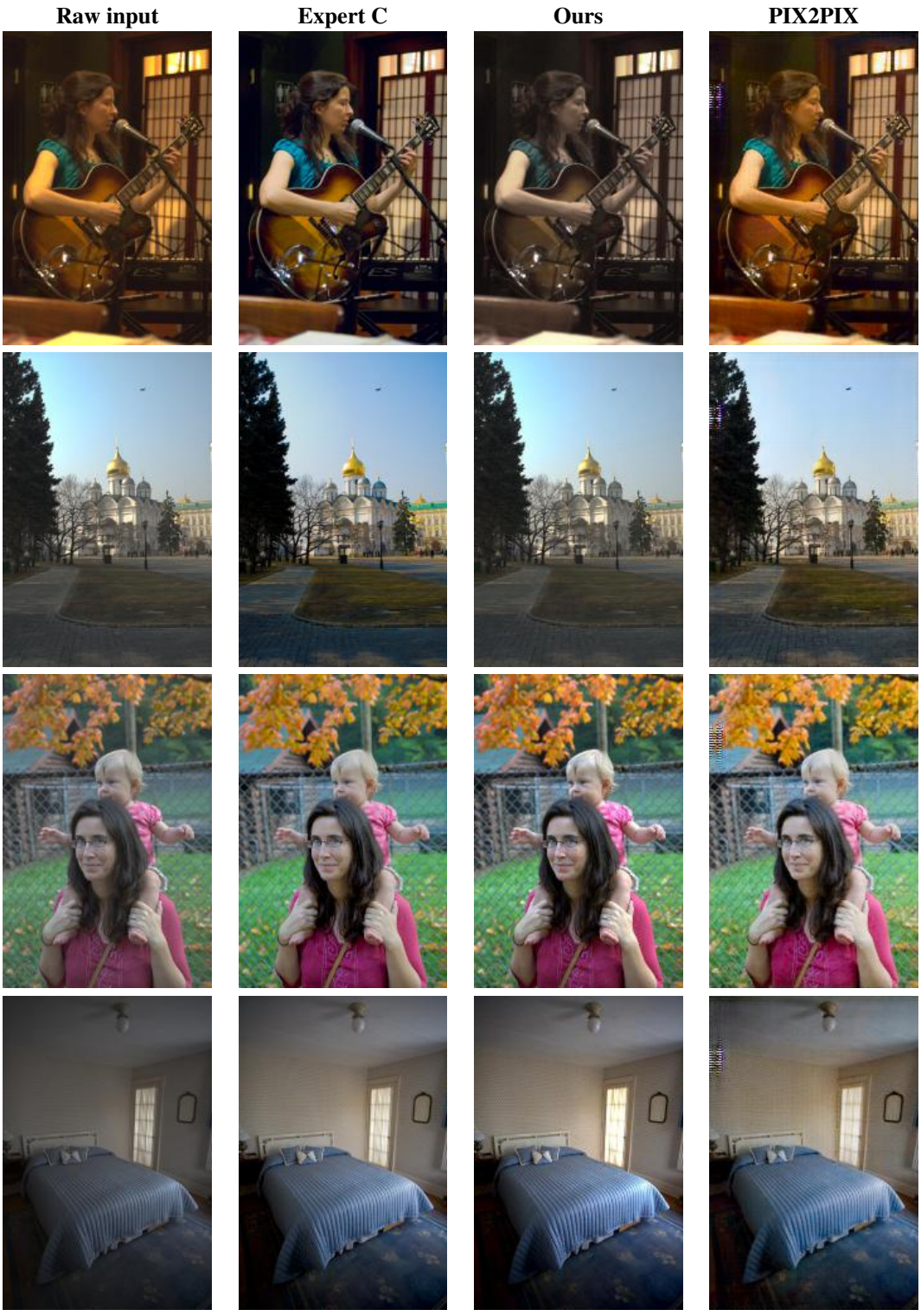


Table 163. [8 / 46] Experiment result using input-retouched image pairs

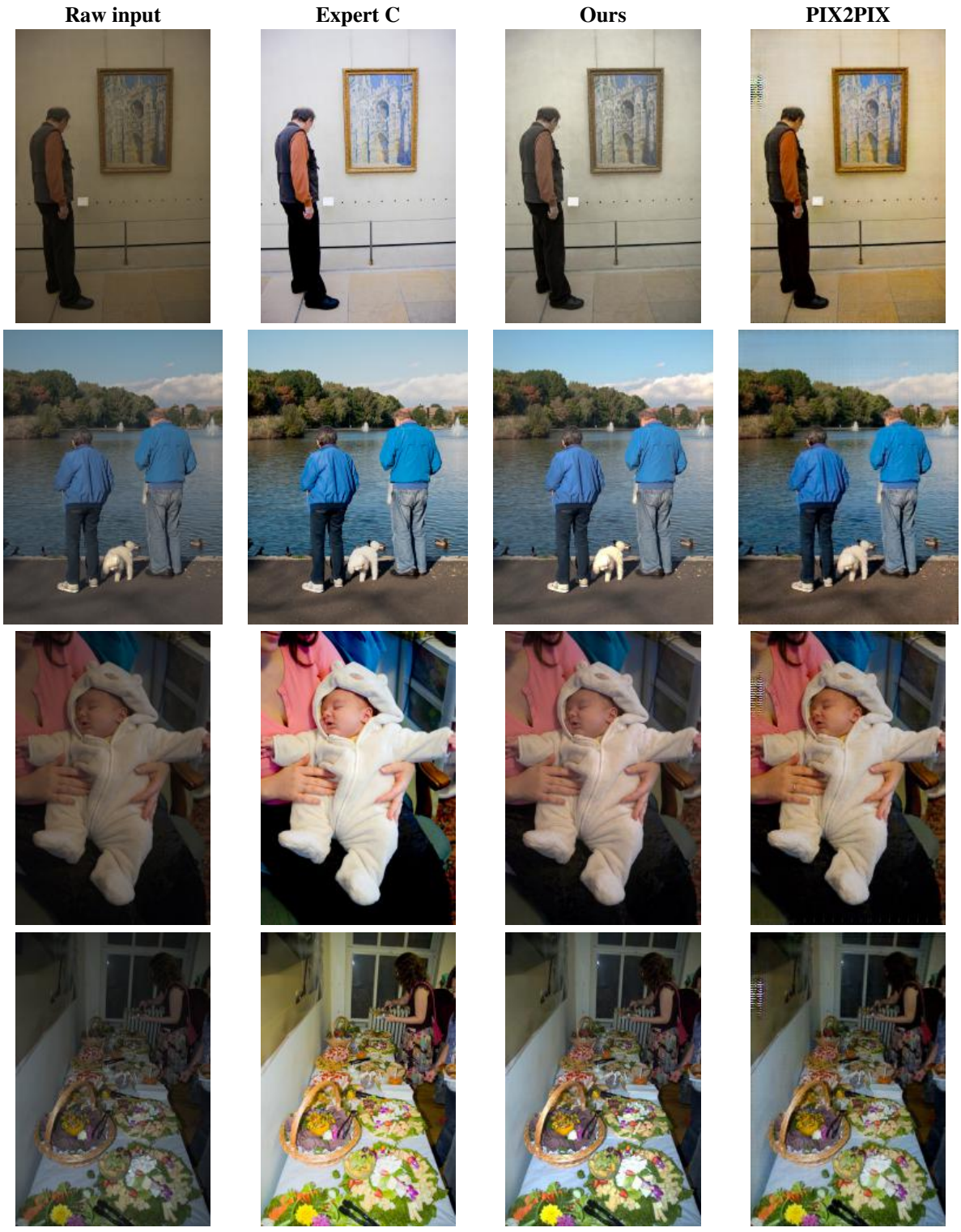


Table 164. [9 / 46] Experiment result using input-retouched image pairs

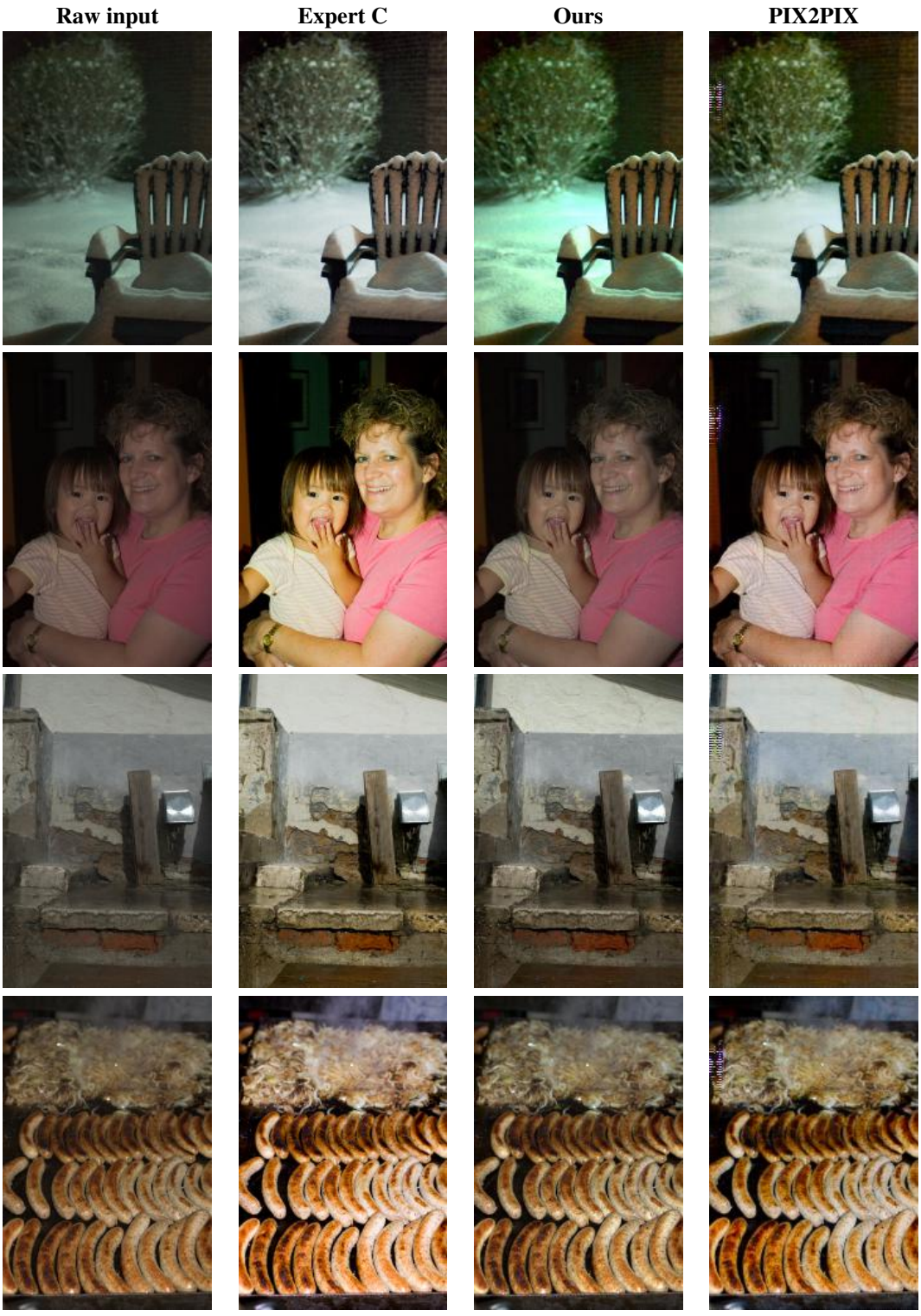


Table 165. [10 / 46] Experiment result using input-retouched image pairs

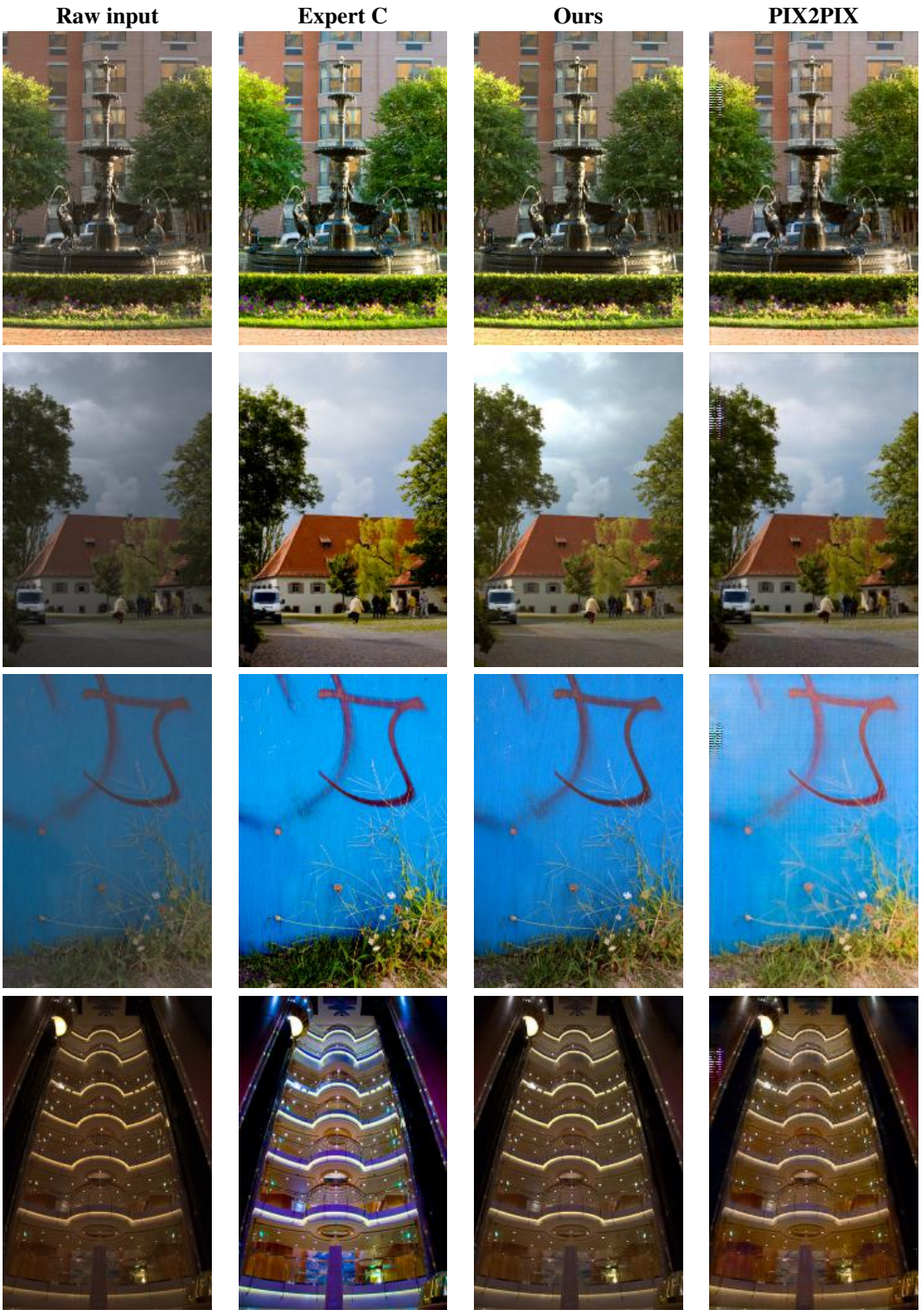


Table 166. [11 / 46] Experiment result using input-retouched image pairs

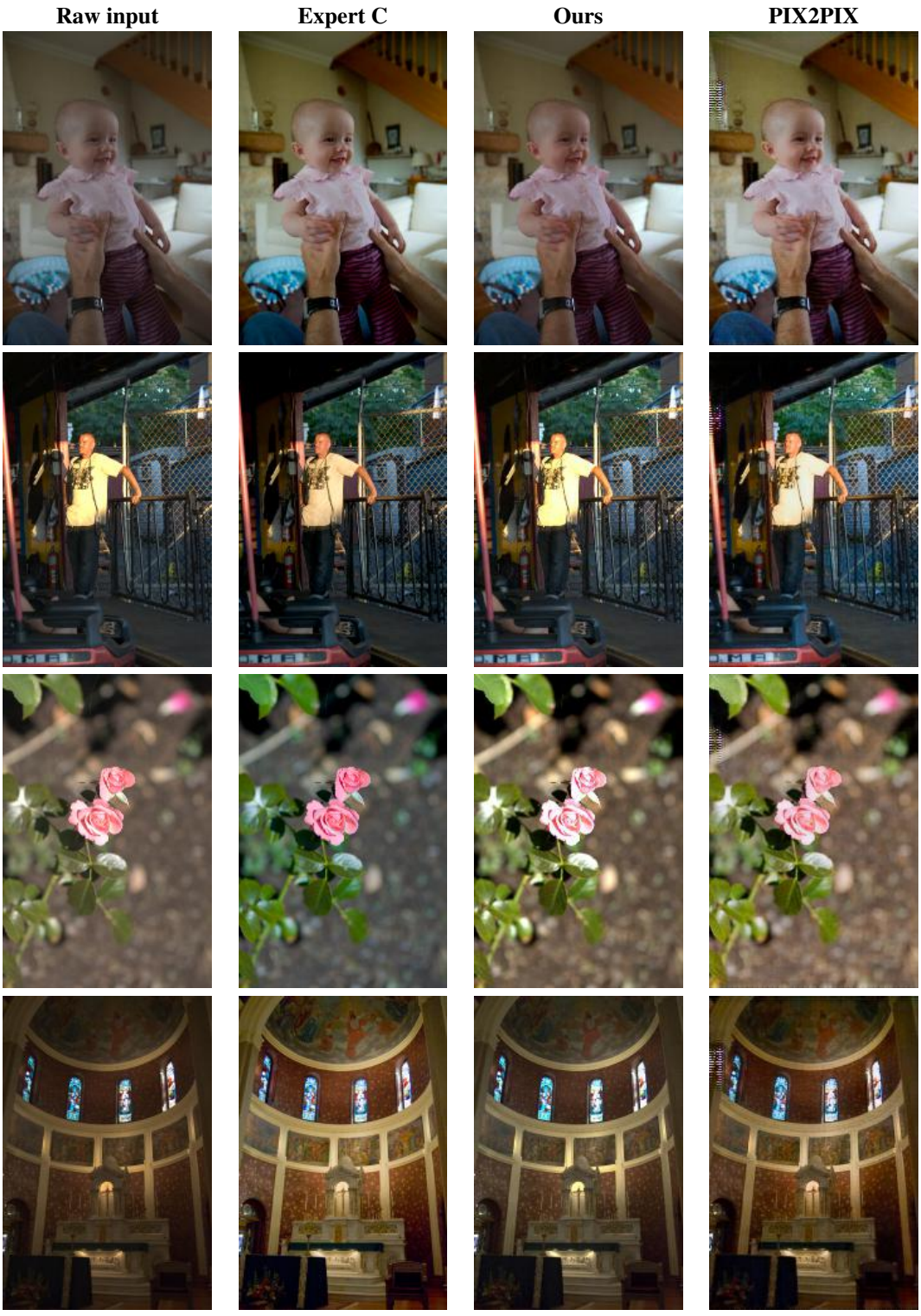


Table 167. [12 / 46] Experiment result using input-retouched image pairs

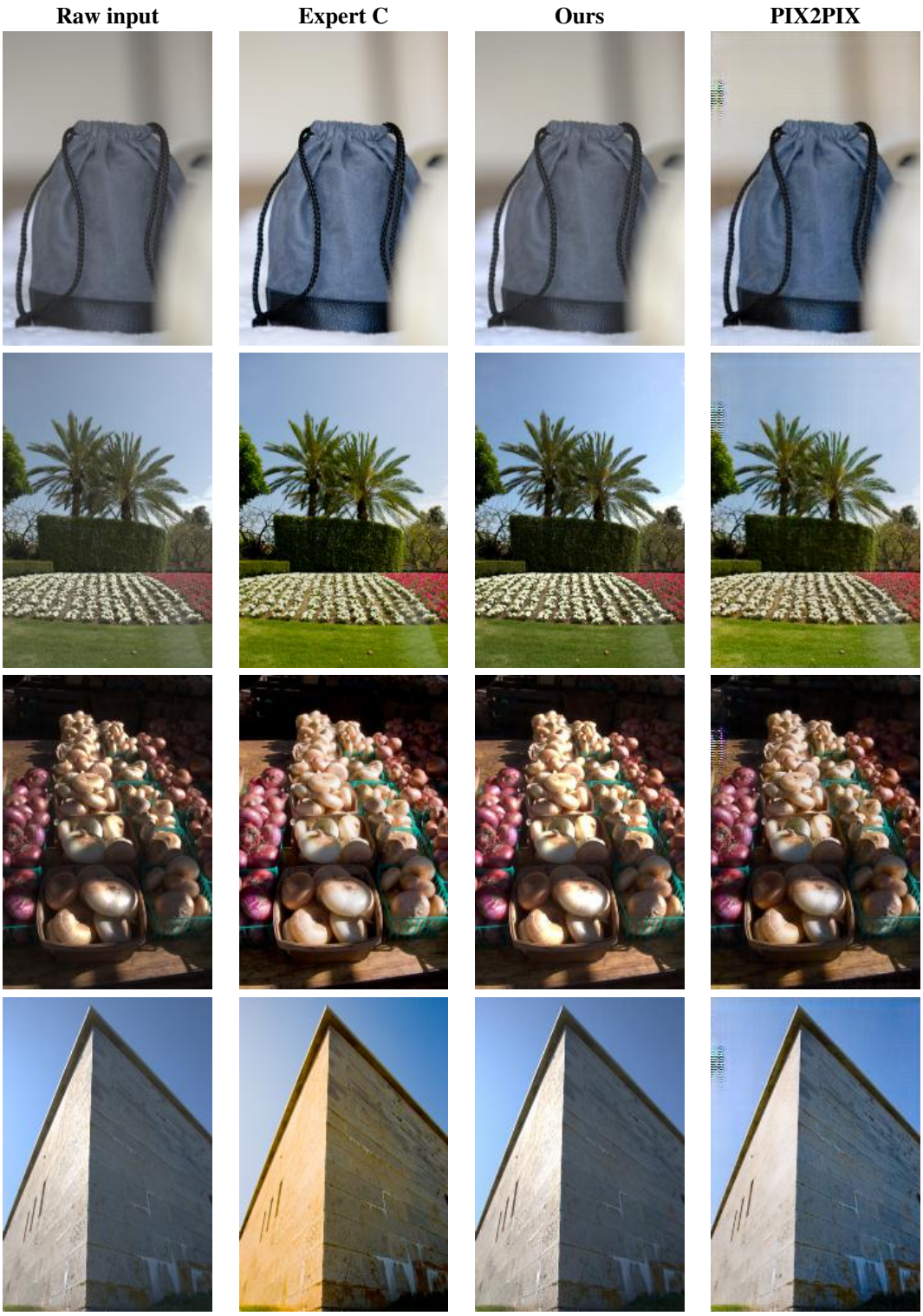


Table 168. [13 / 46] Experiment result using input-retouched image pairs

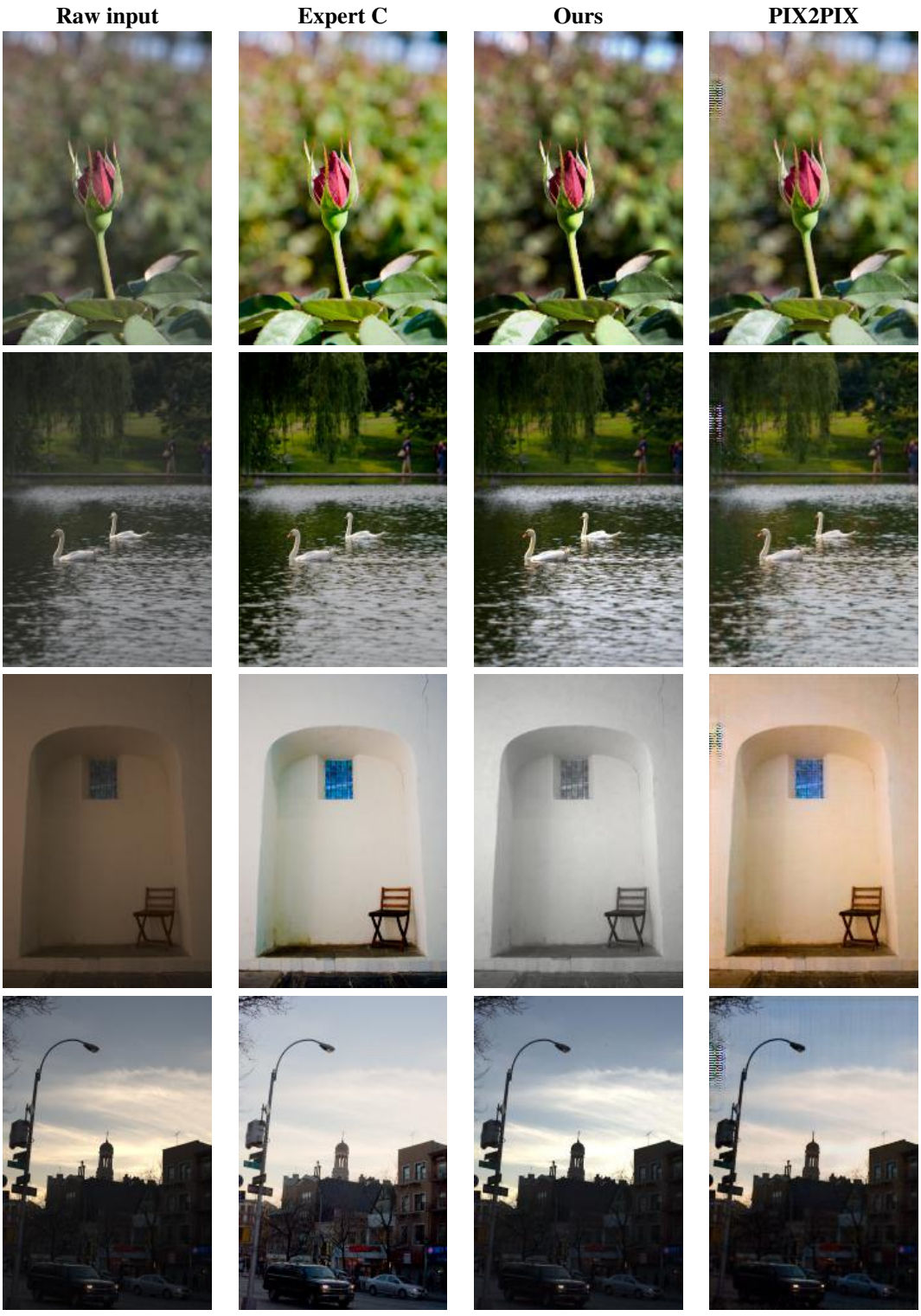


Table 169. [14 / 46] Experiment result using input-retouched image pairs

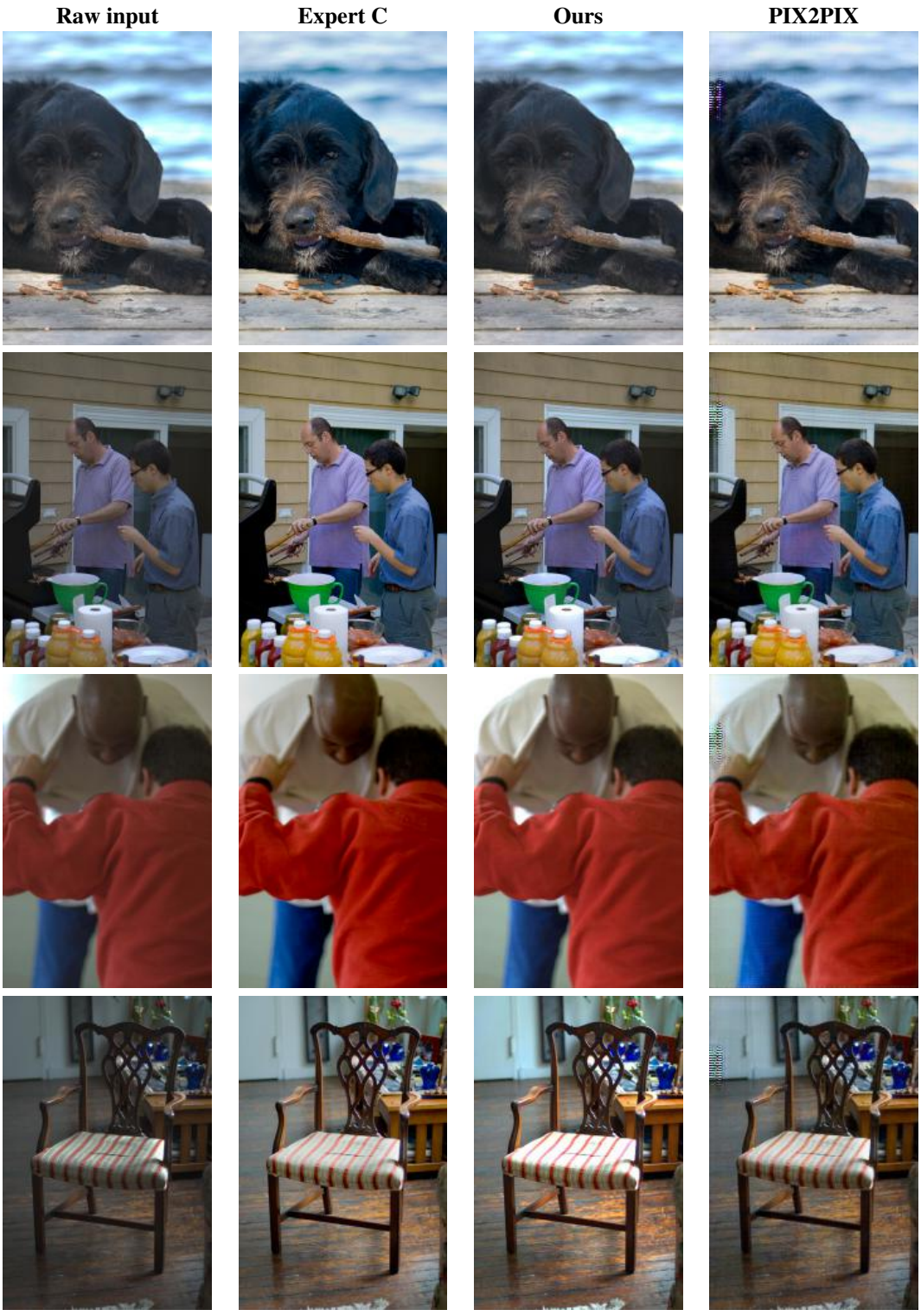


Table 170. [15 / 46] Experiment result using input-retouched image pairs

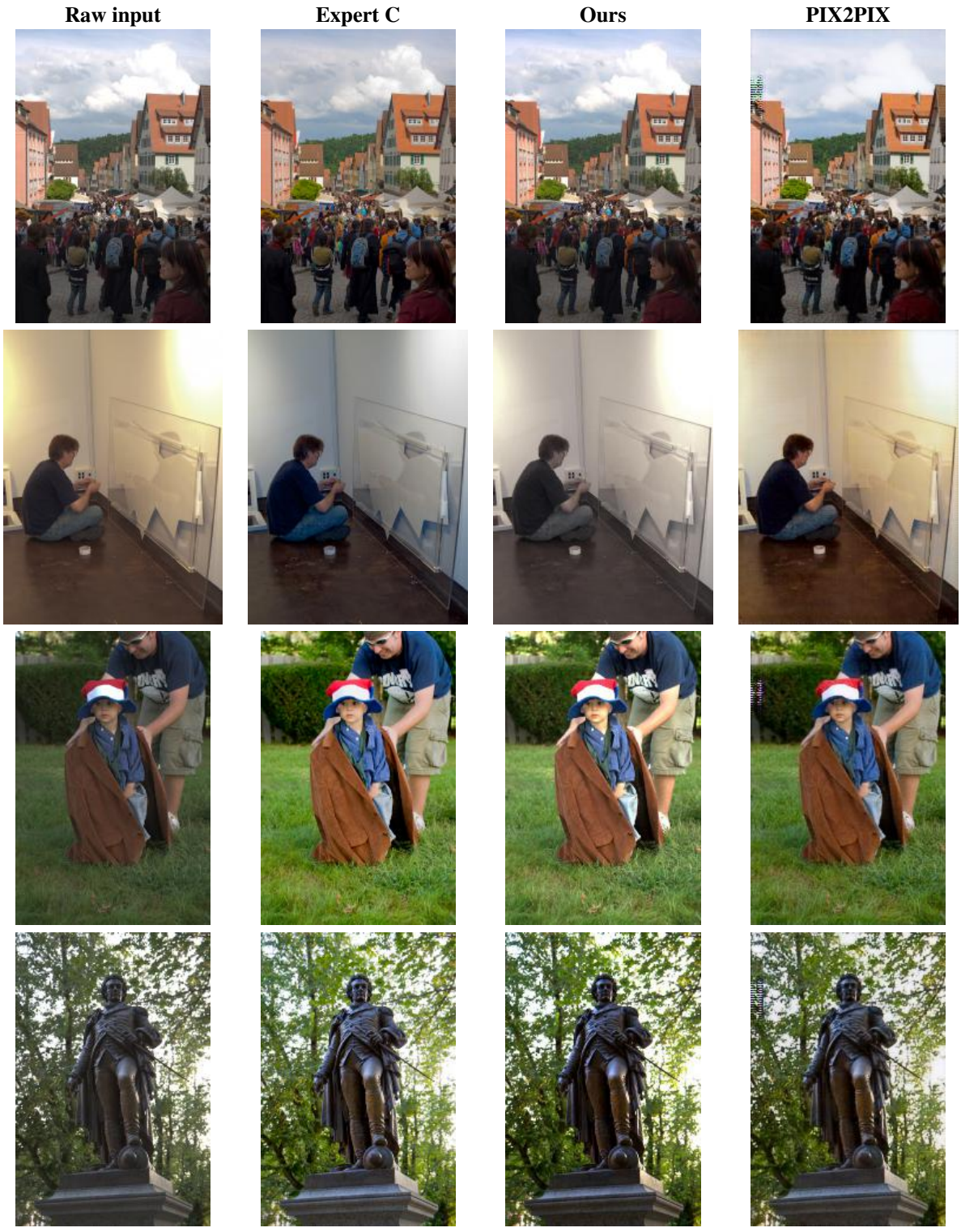


Table 171. [16 / 46] Experiment result using input-retouched image pairs

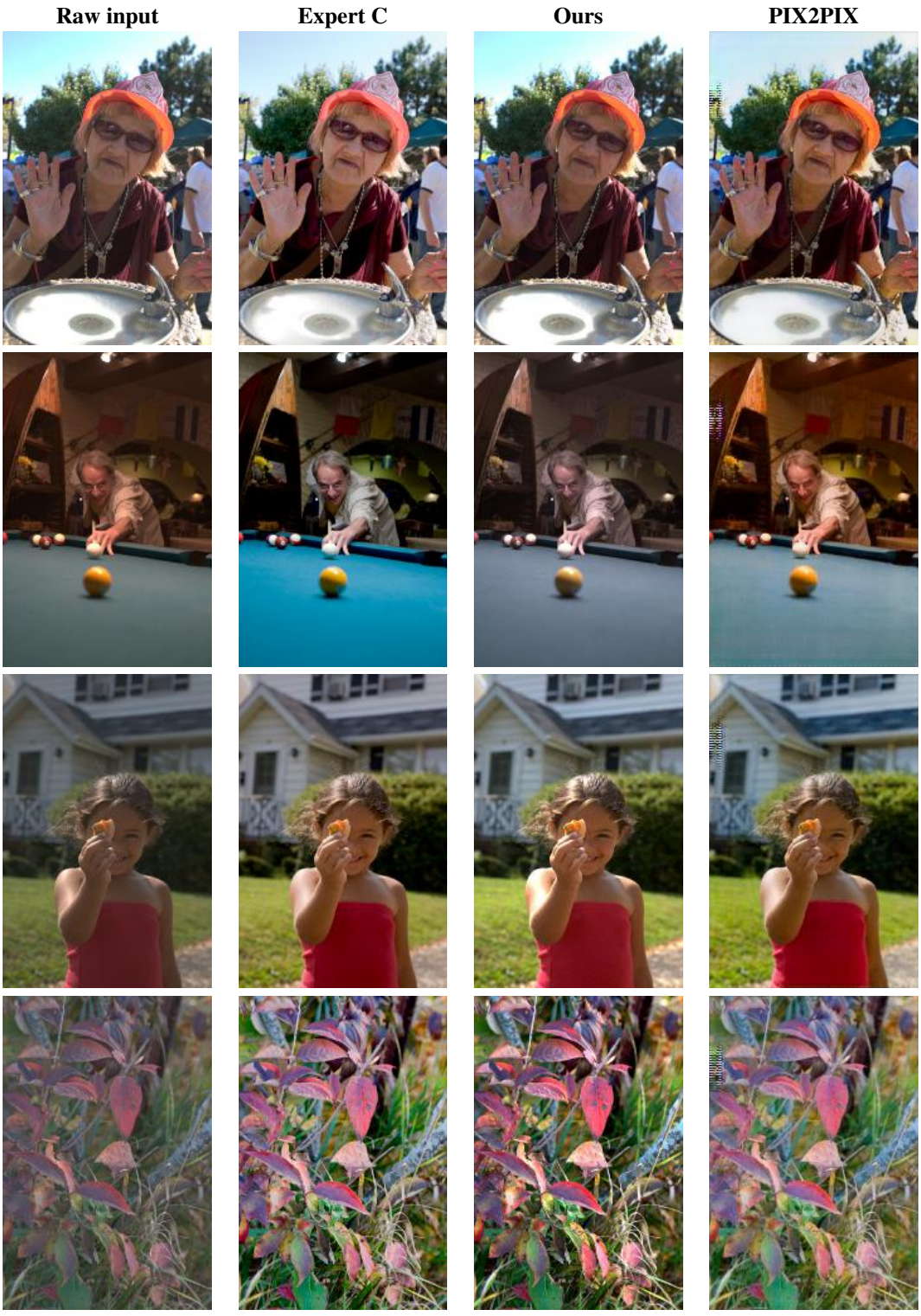


Table 172. [17 / 46] Experiment result using input-retouched image pairs

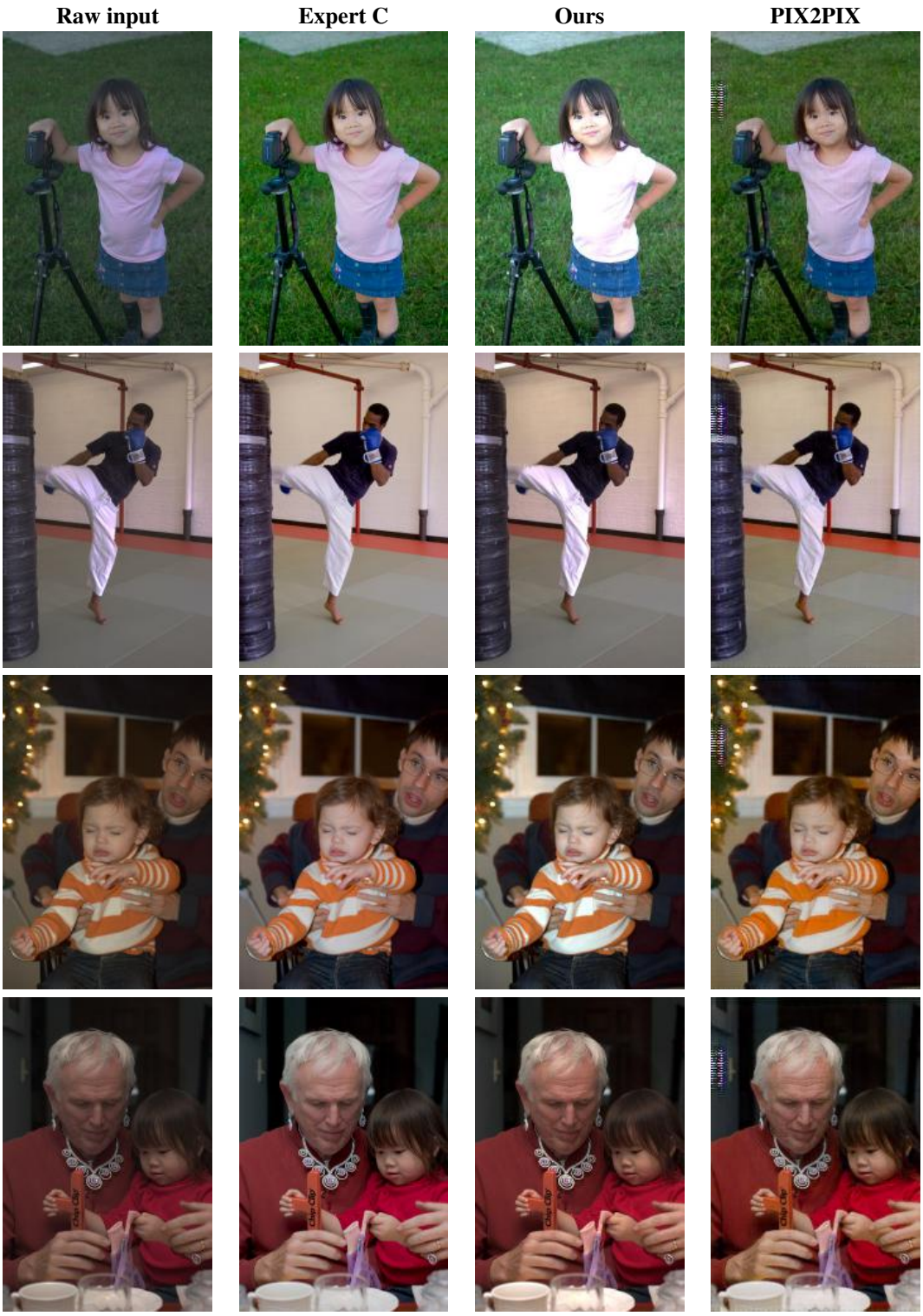


Table 173. [18 / 46] Experiment result using input-retouched image pairs

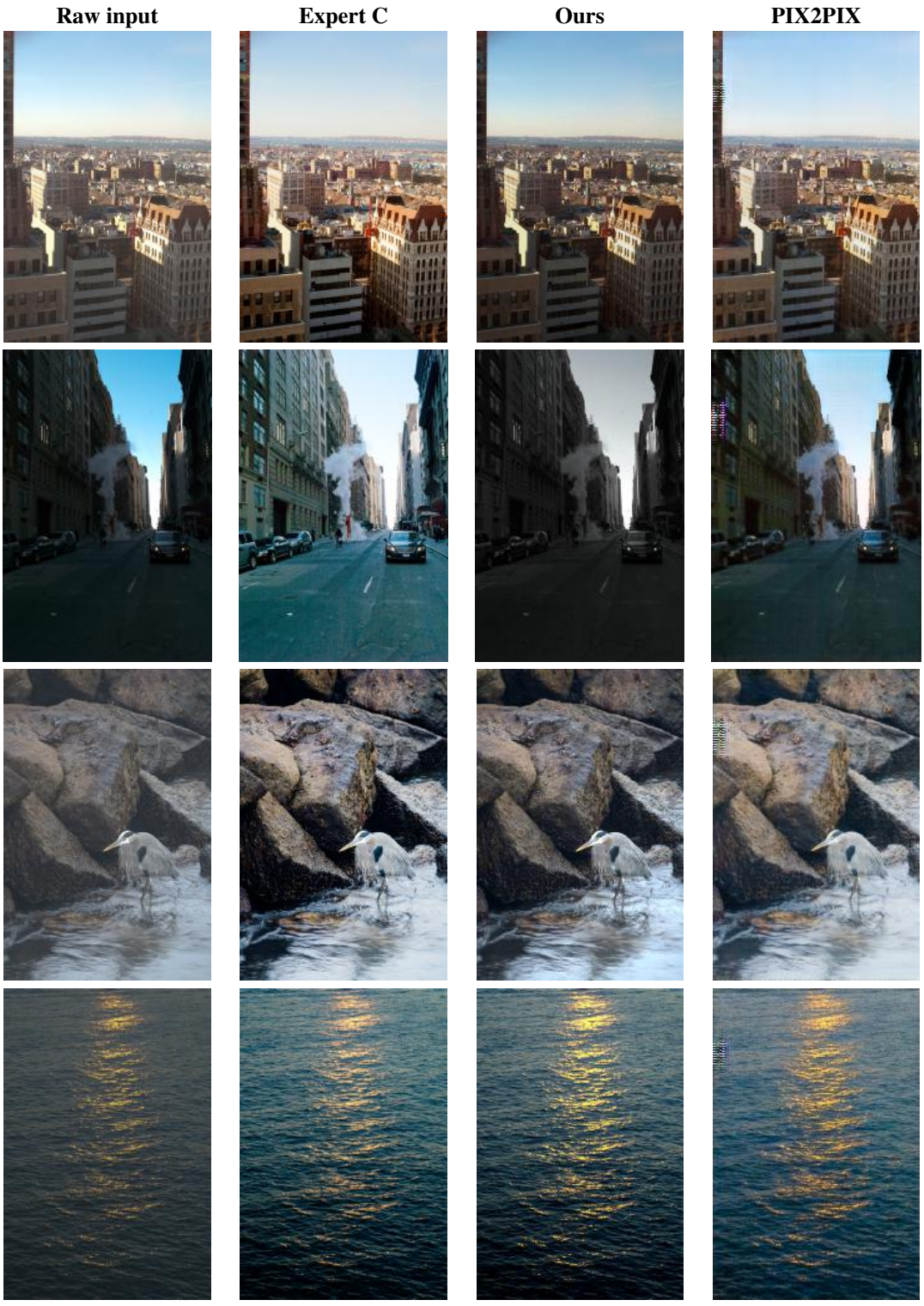


Table 174. [19 / 46] Experiment result using input-retouched image pairs

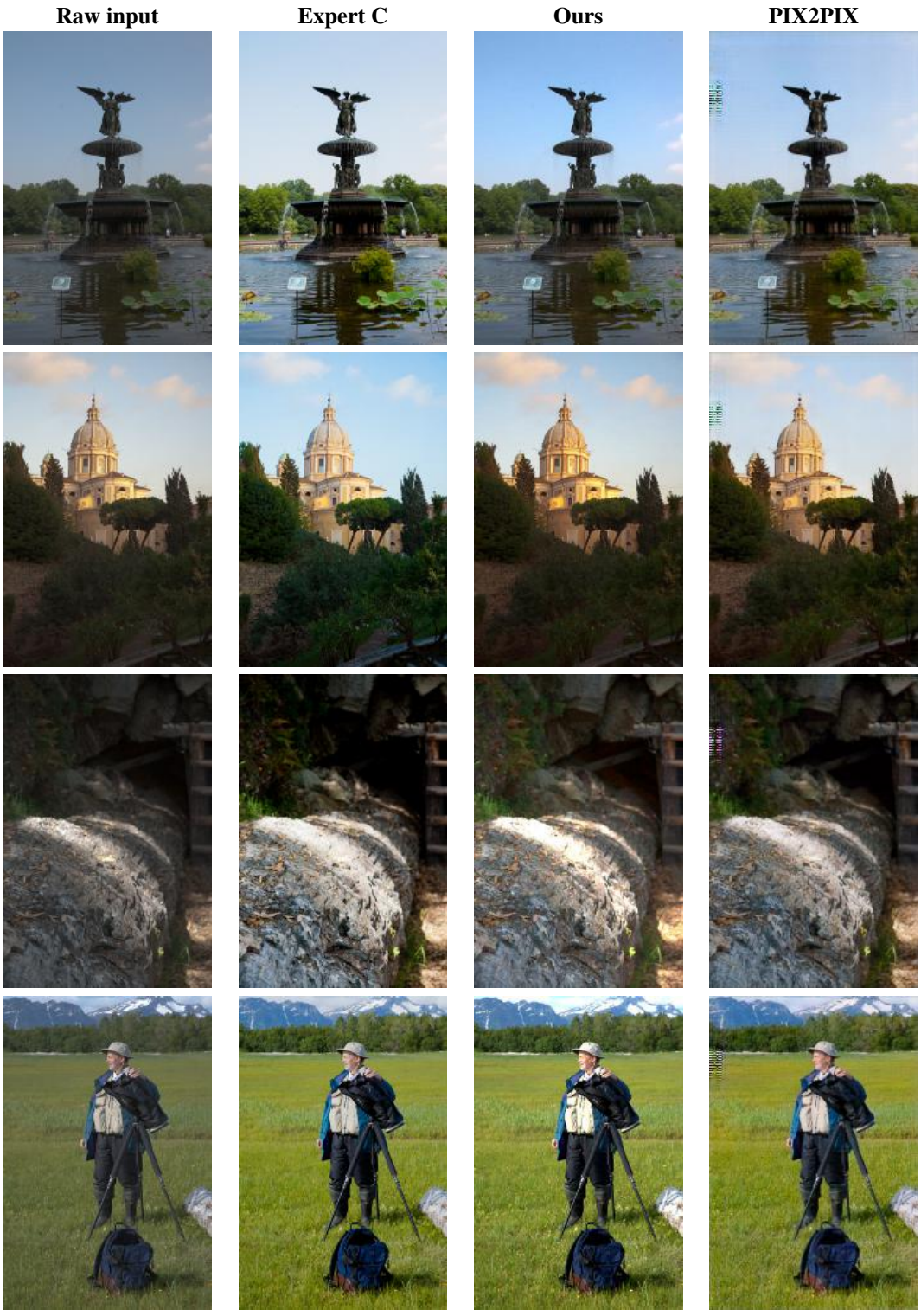


Table 175. [20 / 46] Experiment result using input-retouched image pairs

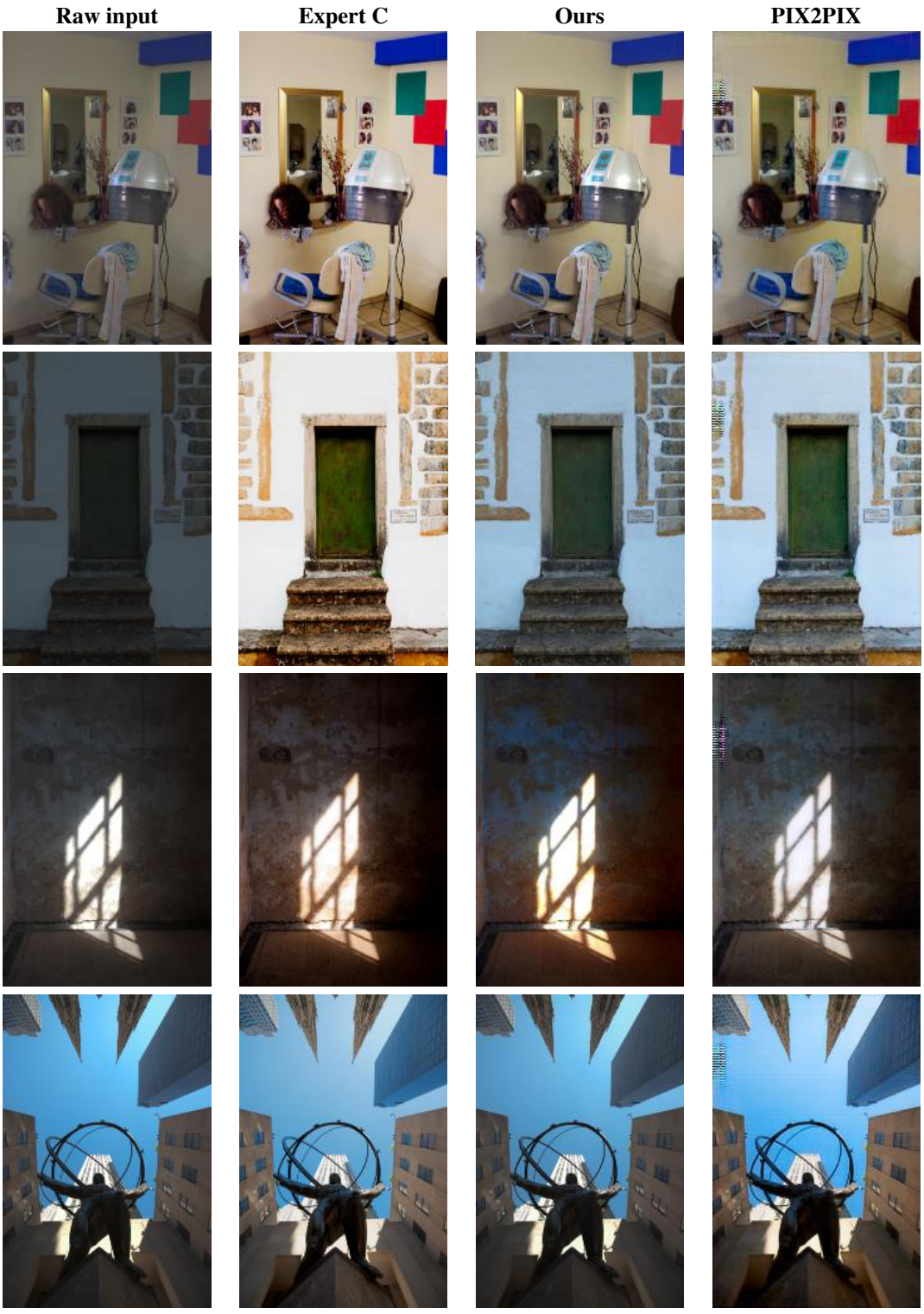


Table 176. [21 / 46] Experiment result using input-retouched image pairs

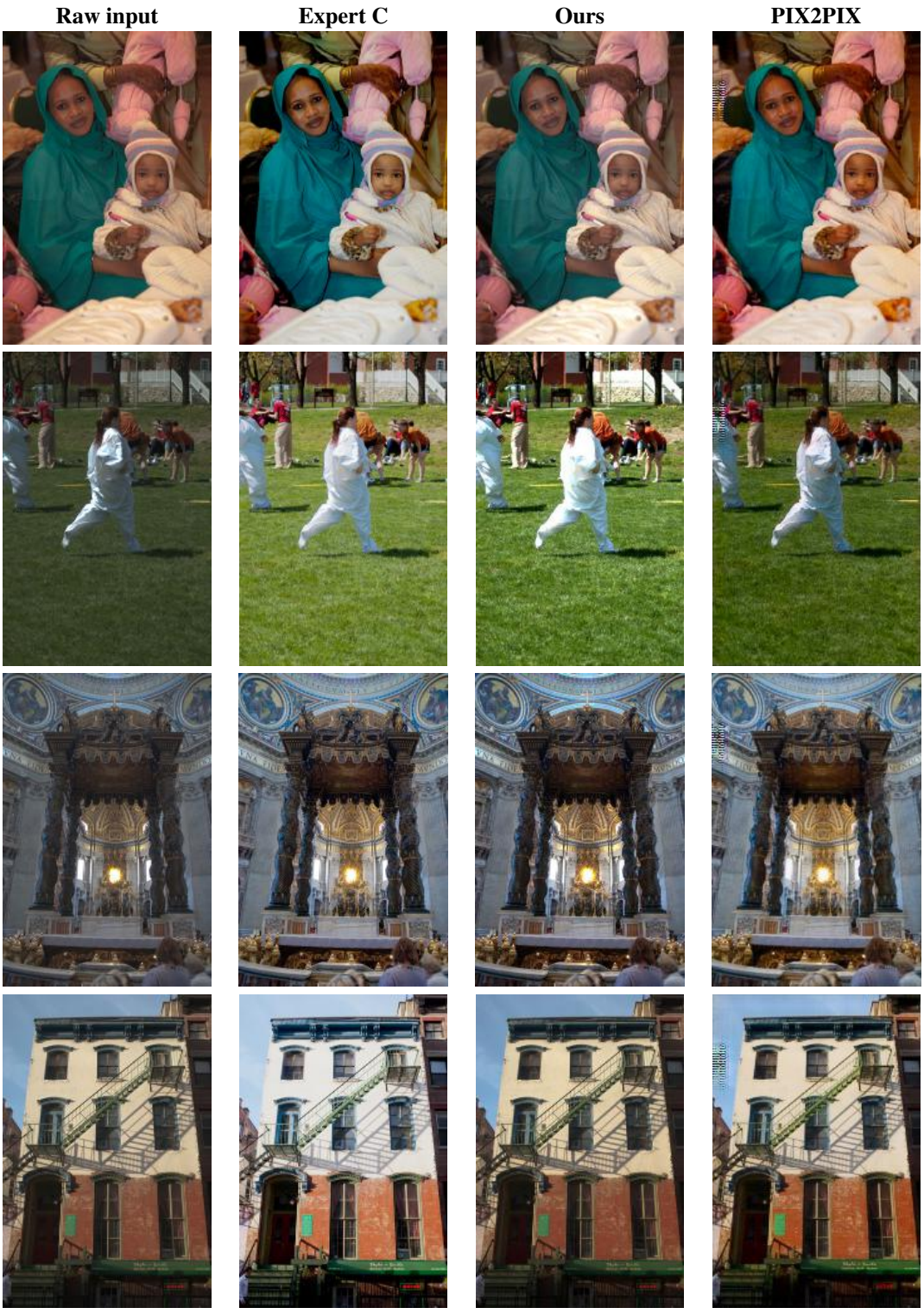


Table 177. [22 / 46] Experiment result using input-retouched image pairs

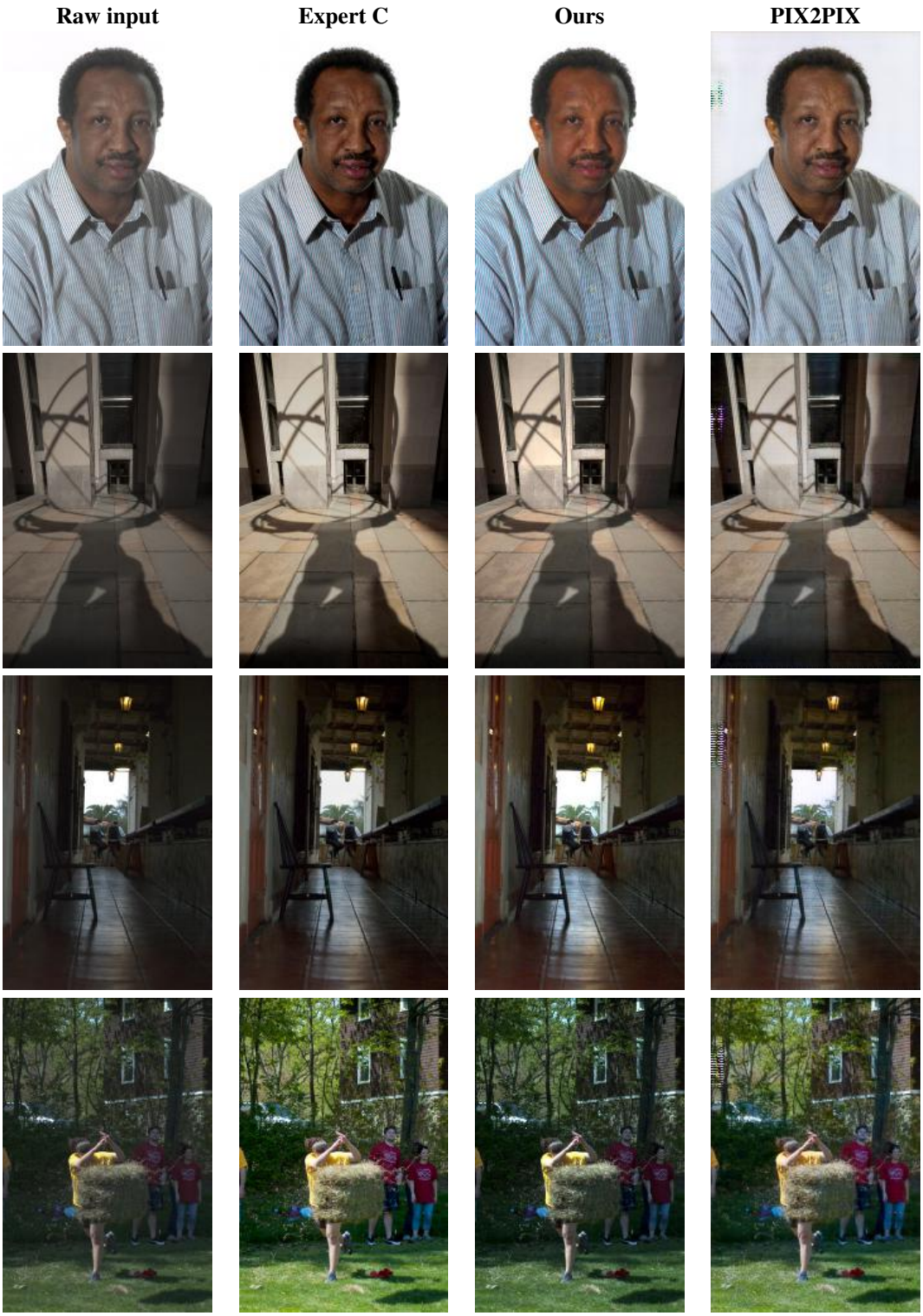


Table 178. [23 / 46] Experiment result using input-retouched image pairs

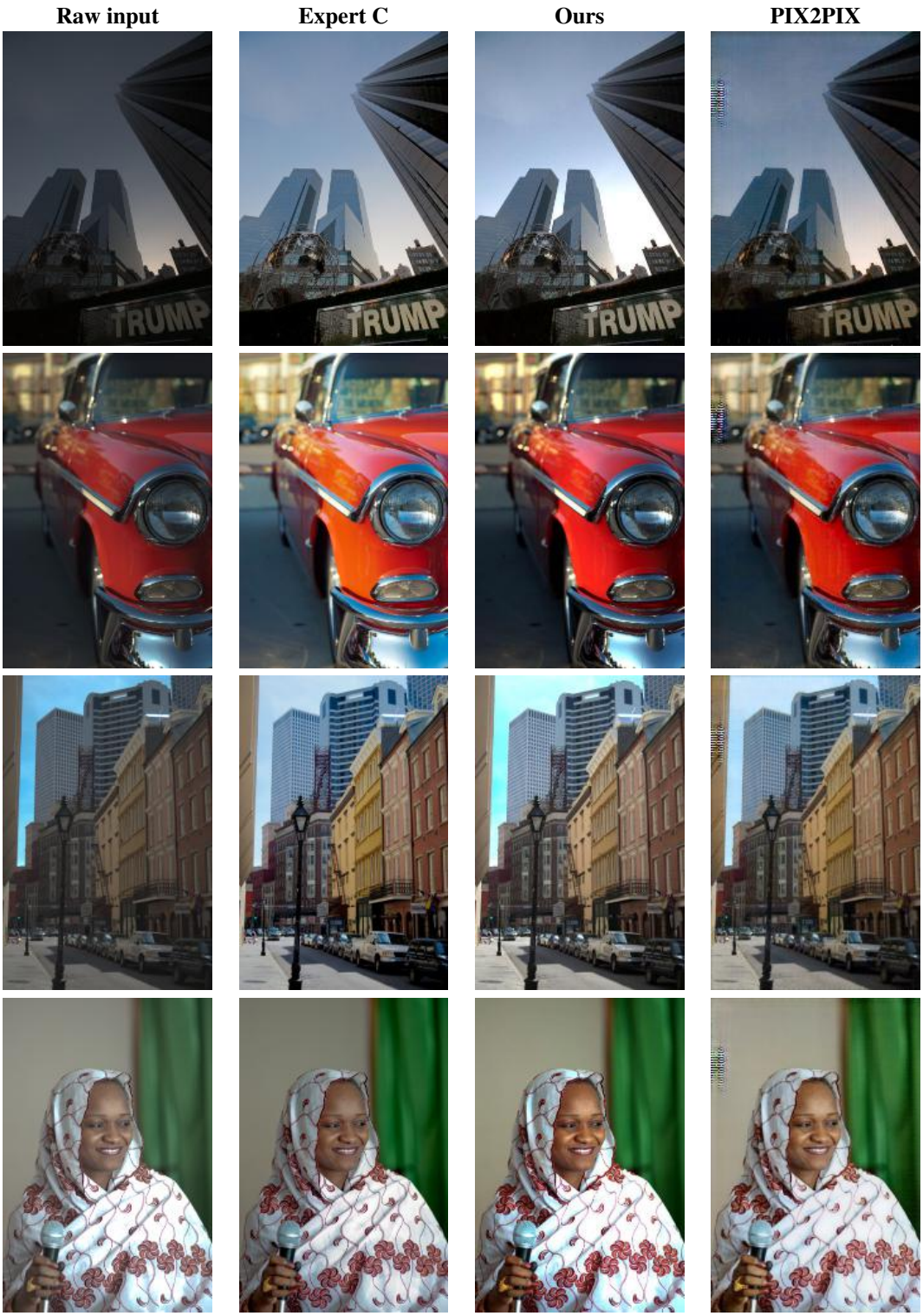


Table 179. [24 / 46] Experiment result using input-retouched image pairs

Table 180. [25 / 46] Experiment result using input-retouched image pairs

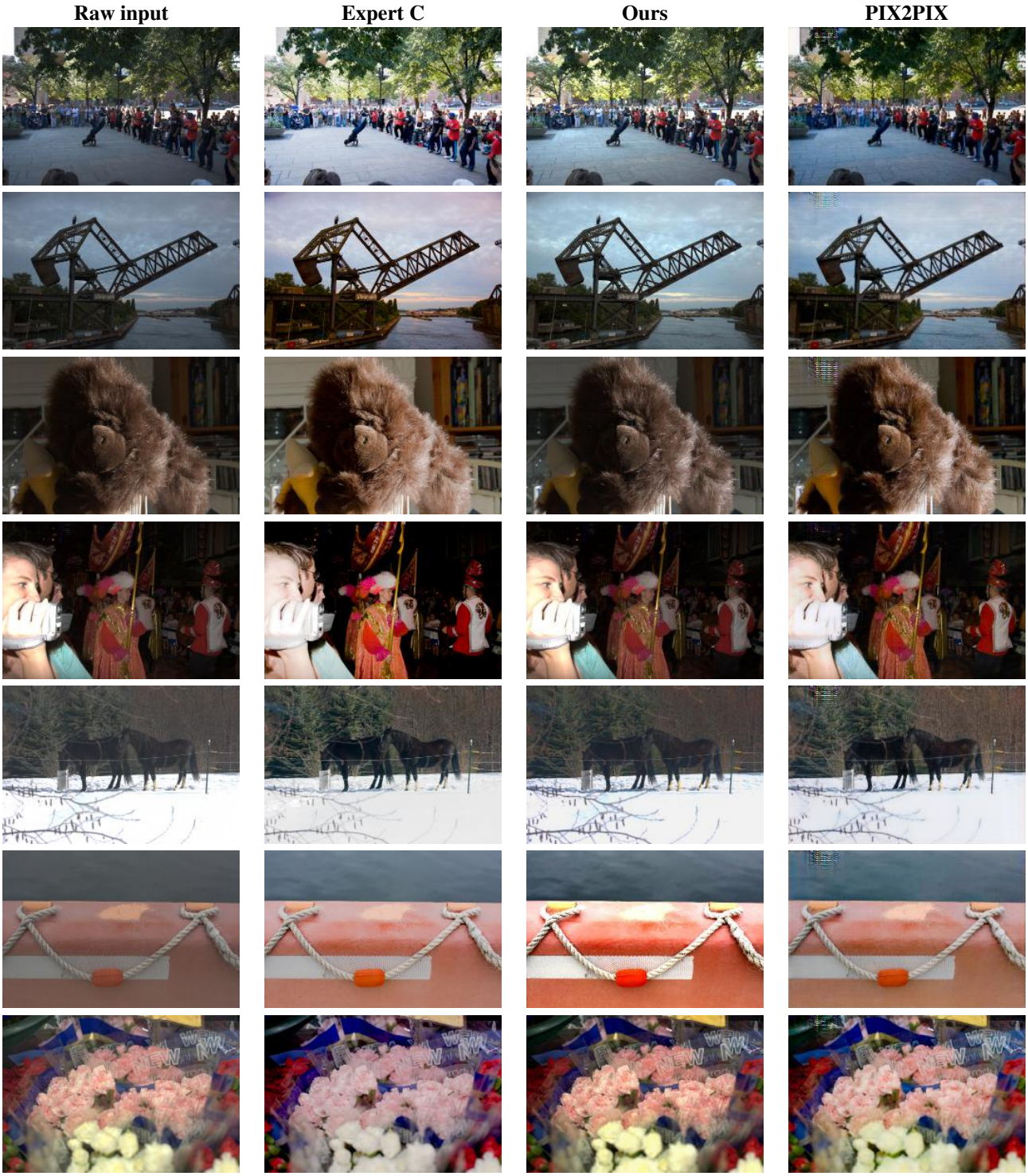


Table 181. [26 / 46] Experiment result using input-retouched image pairs

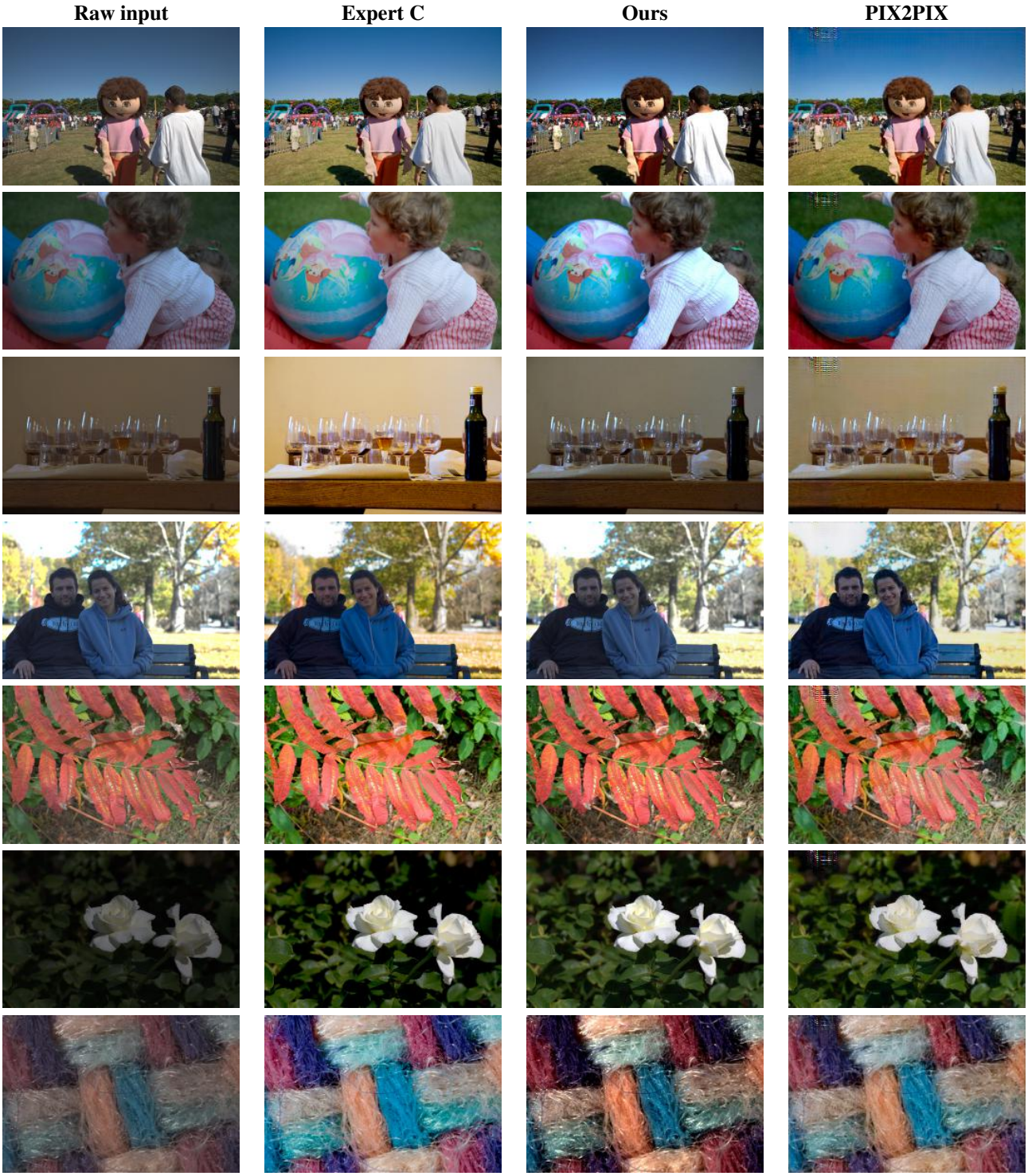


Table 182. [27 / 46] Experiment result using input-retouched image pairs

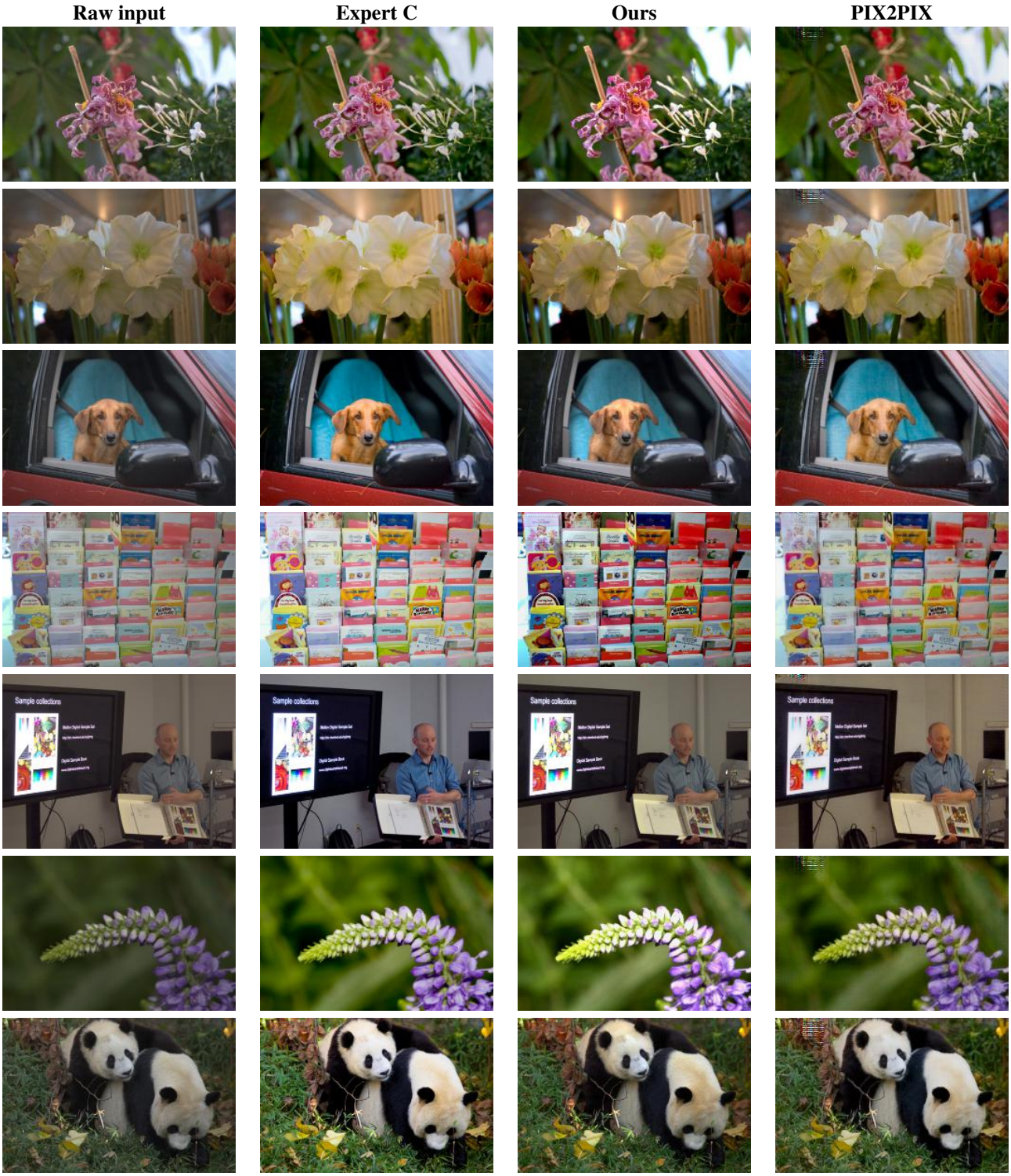


Table 183. [28 / 46] Experiment result using input-retouched image pairs

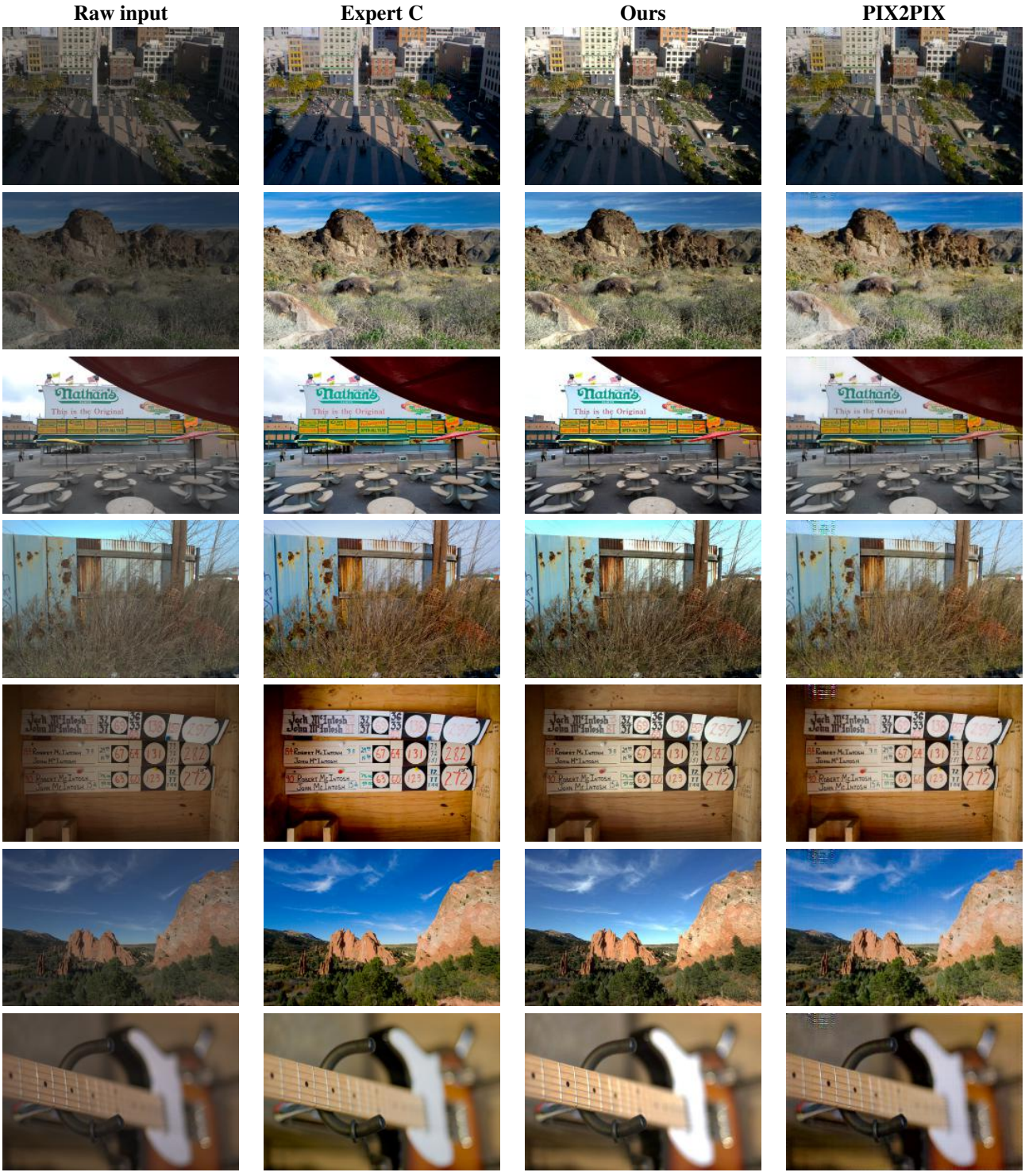


Table 184. [29 / 46] Experiment result using input-retouched image pairs

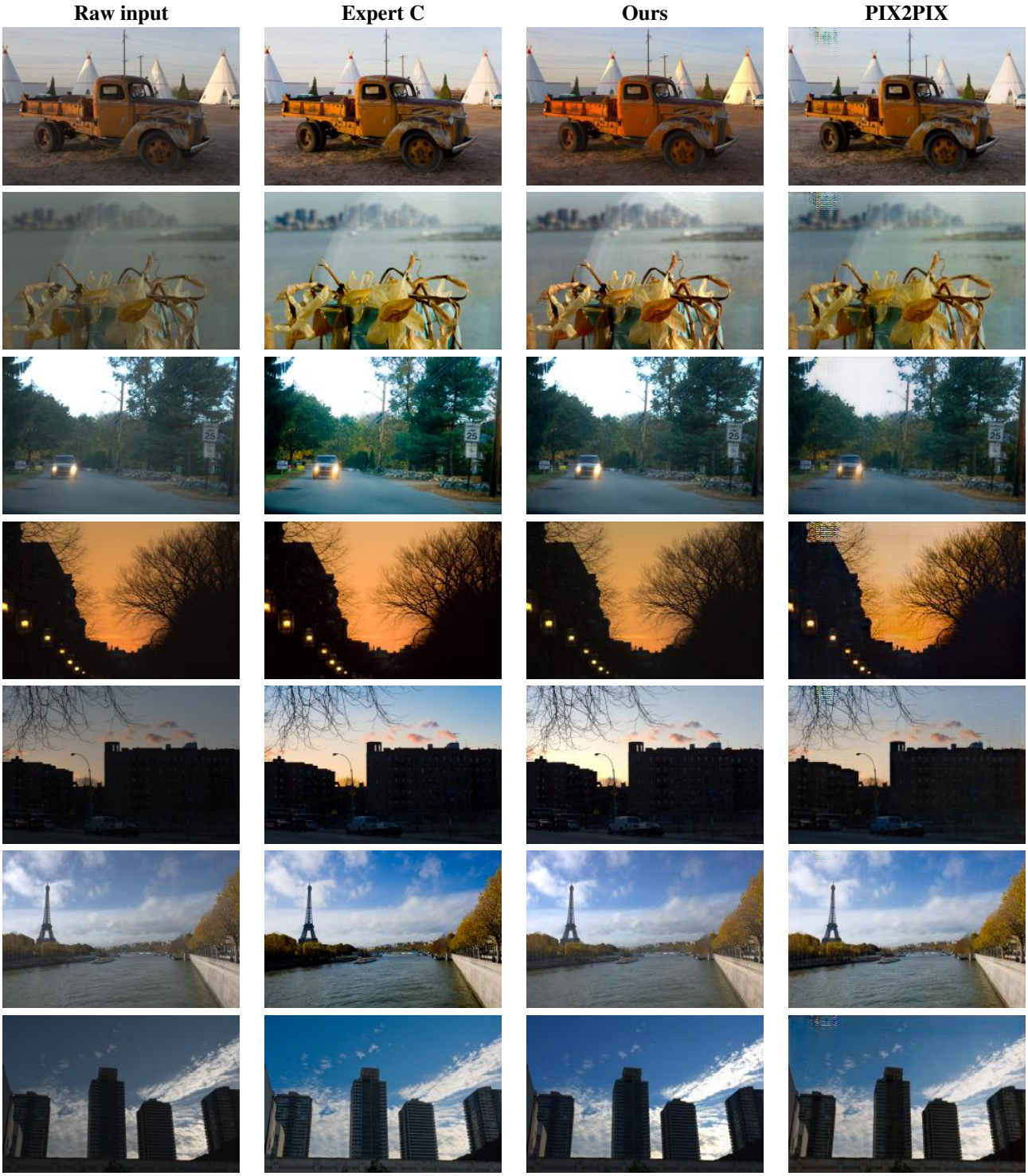


Table 185. [30 / 46] Experiment result using input-retouched image pairs

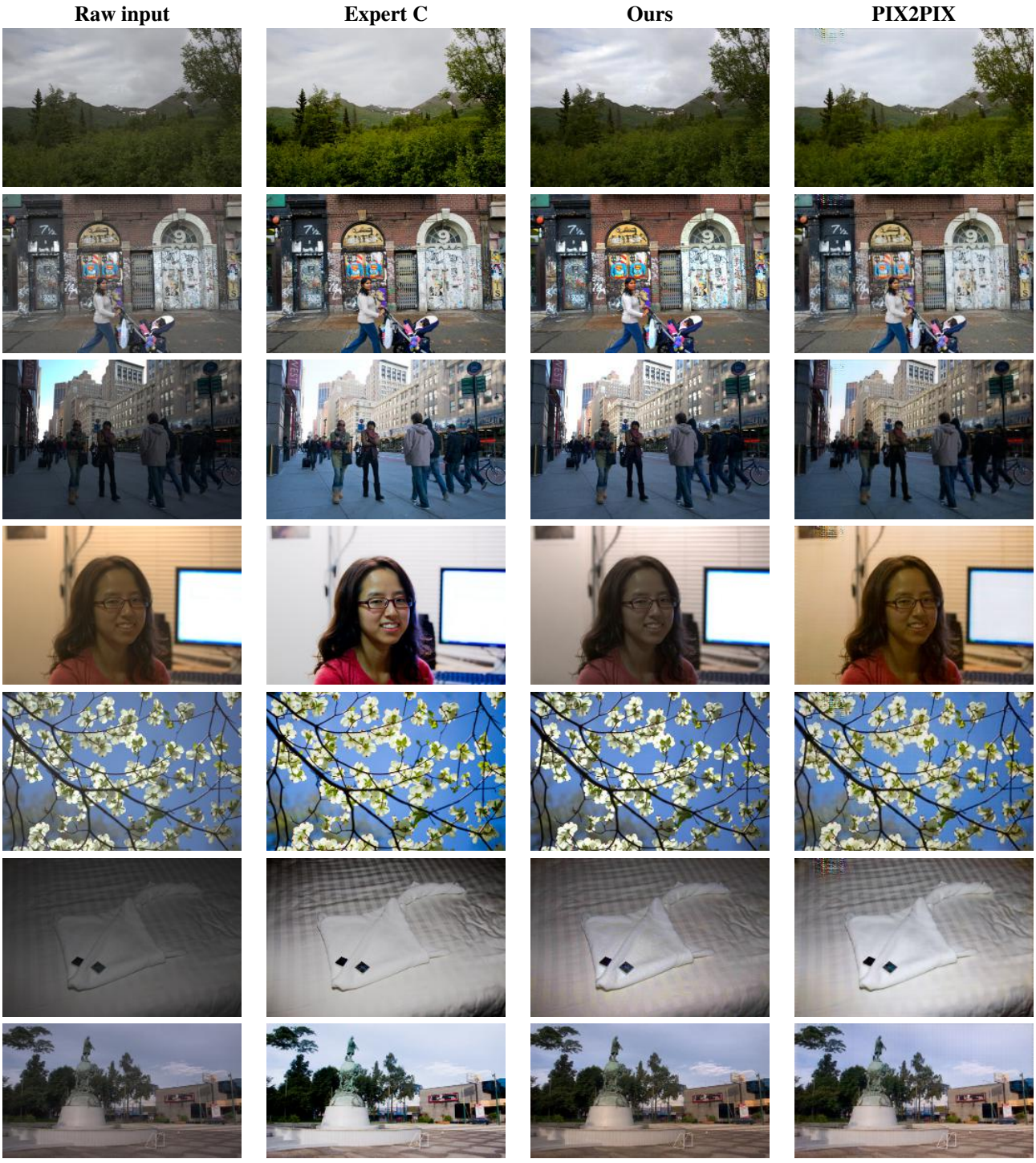


Table 186. [31 / 46] Experiment result using input-retouched image pairs

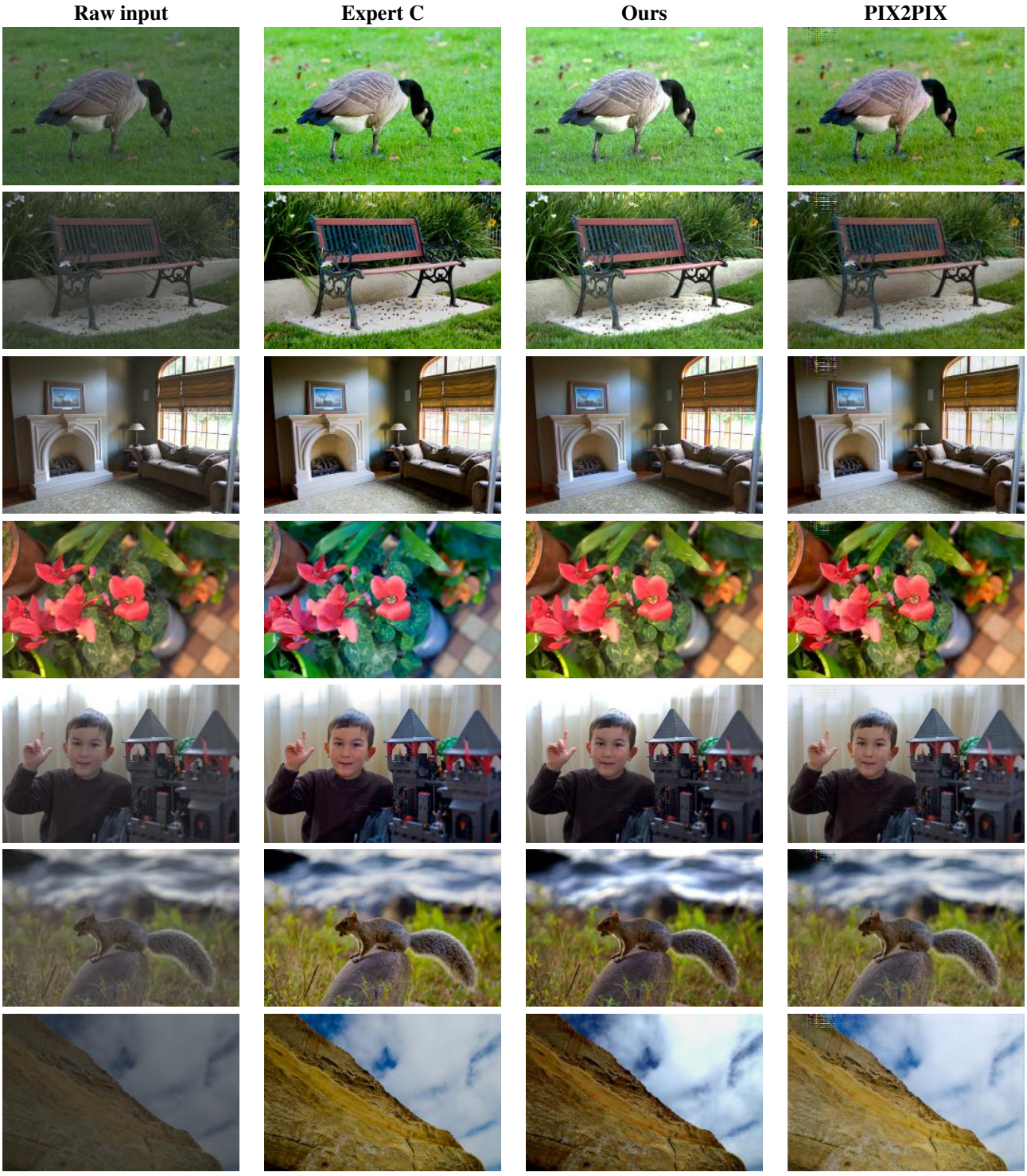


Table 187. [32 / 46] Experiment result using input-retouched image pairs

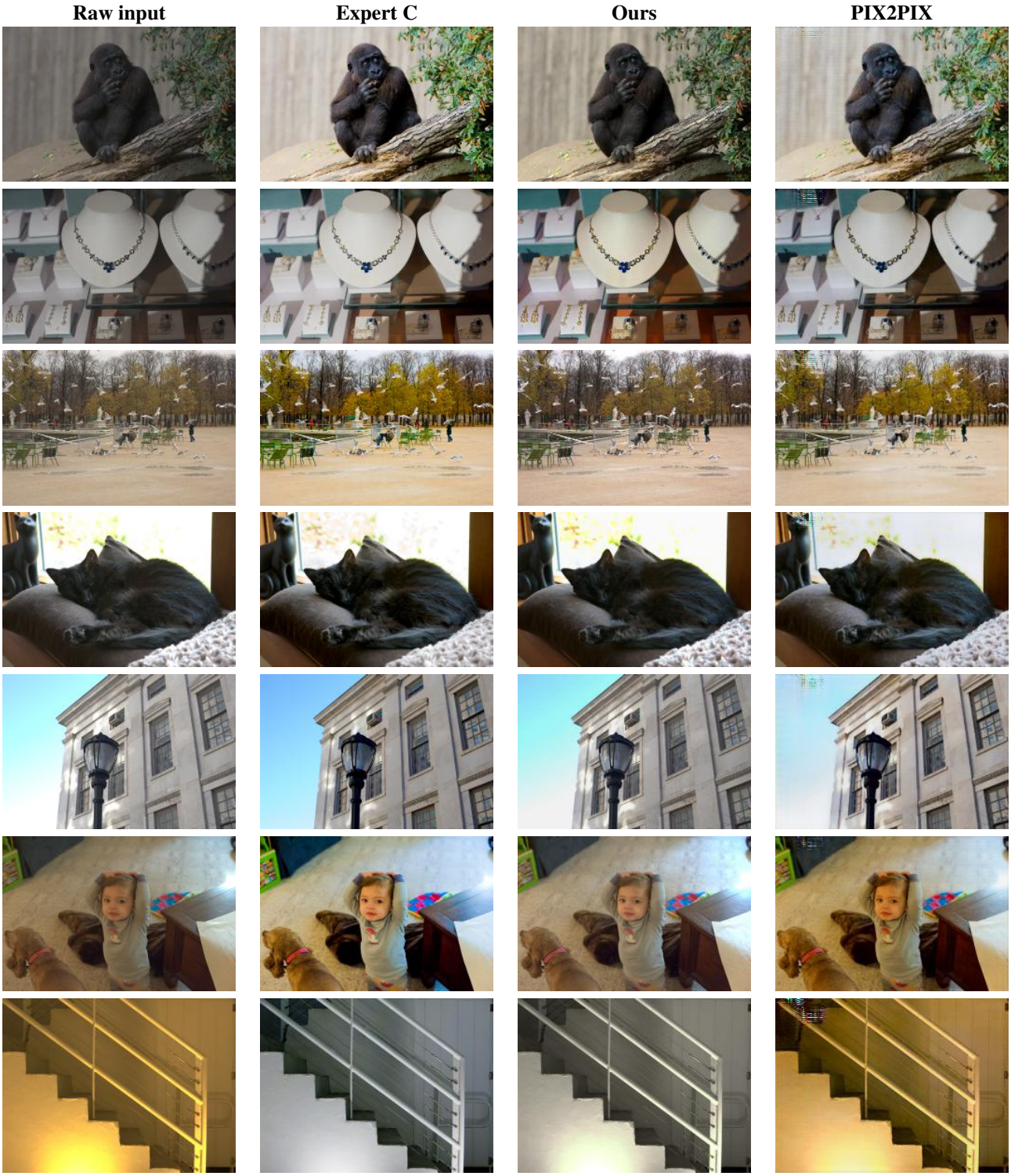


Table 188. [33 / 46] Experiment result using input-retouched image pairs

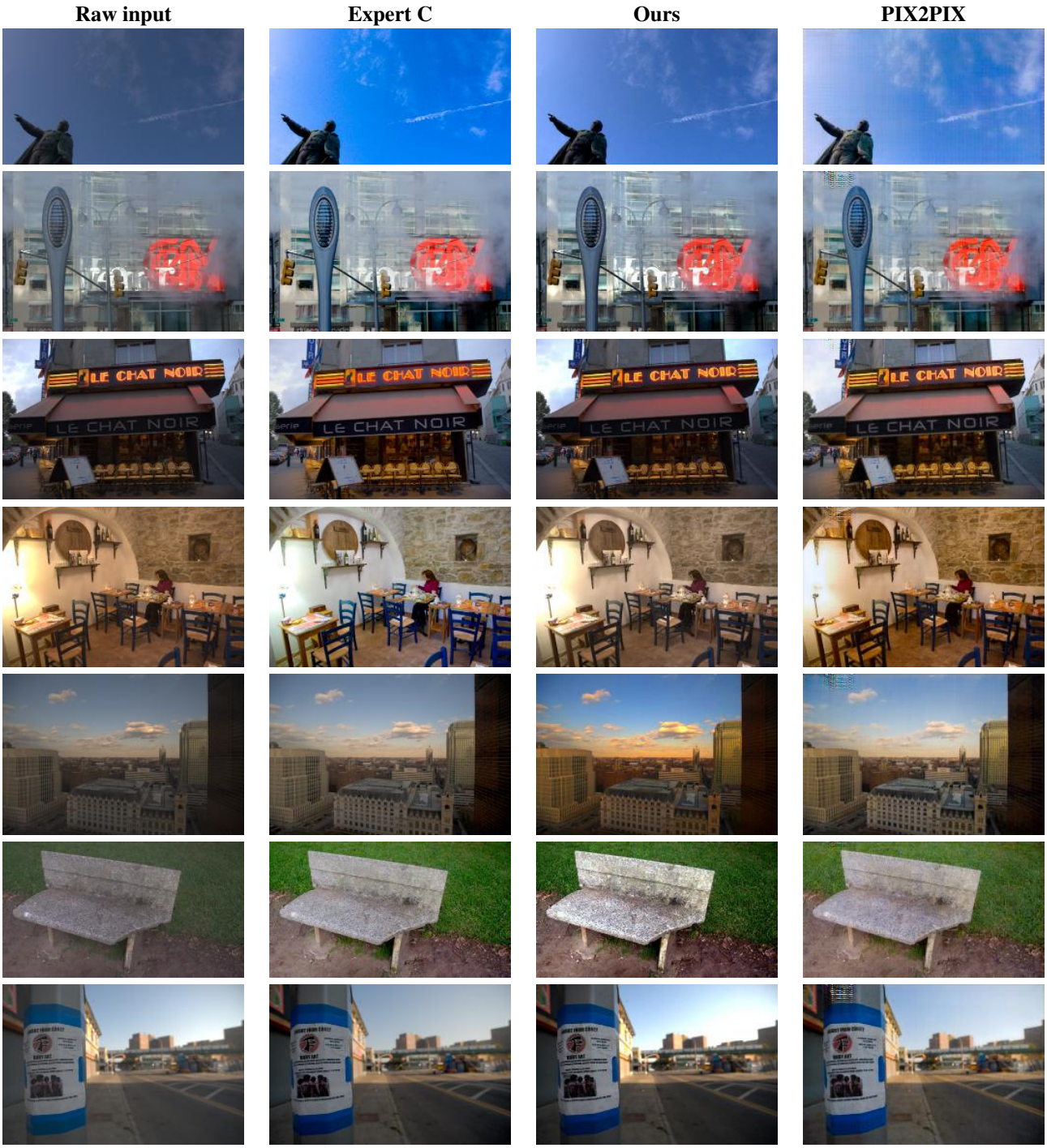


Table 189. [34 / 46] Experiment result using input-retouched image pairs

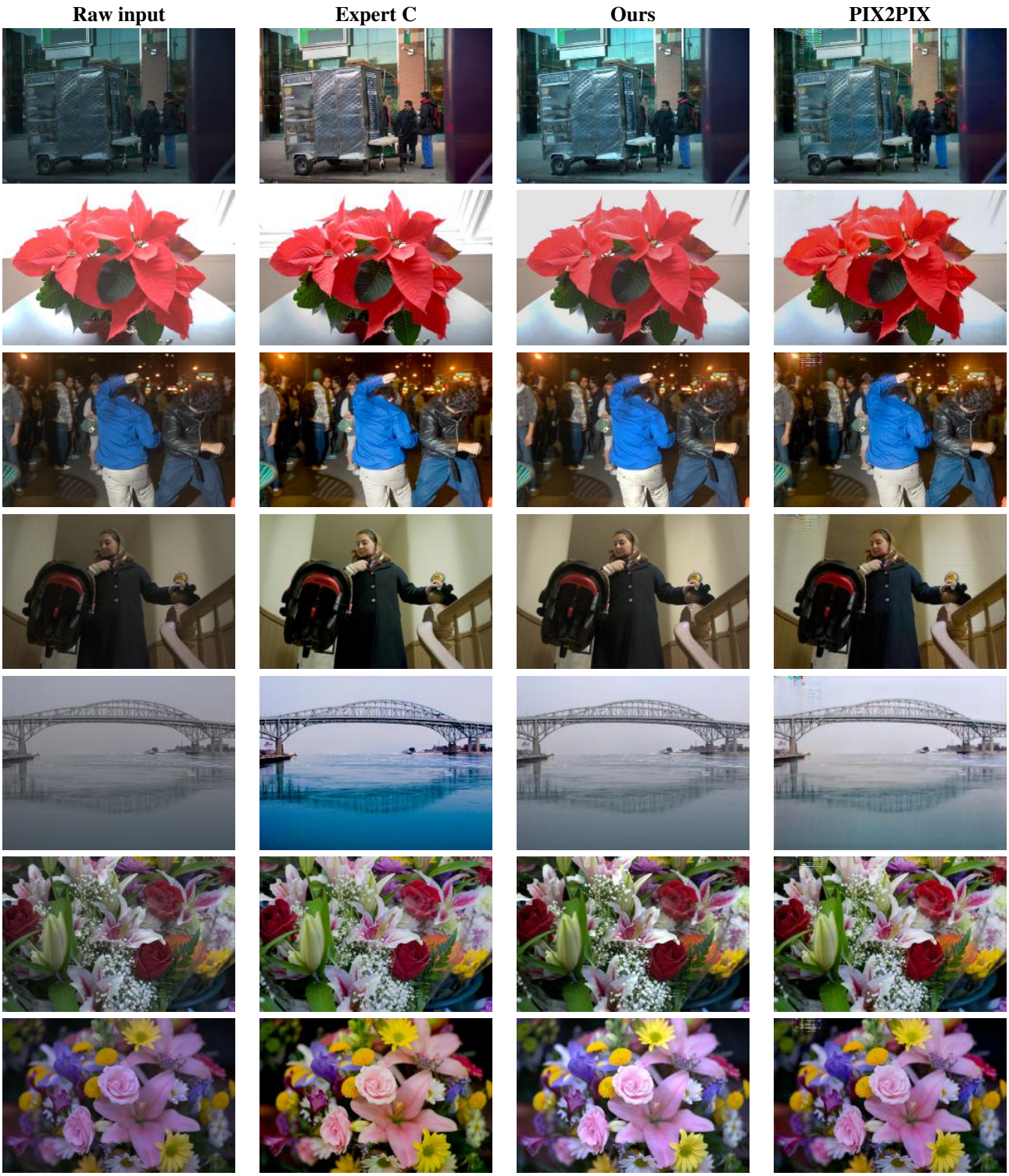


Table 190. [35 / 46] Experiment result using input-retouched image pairs

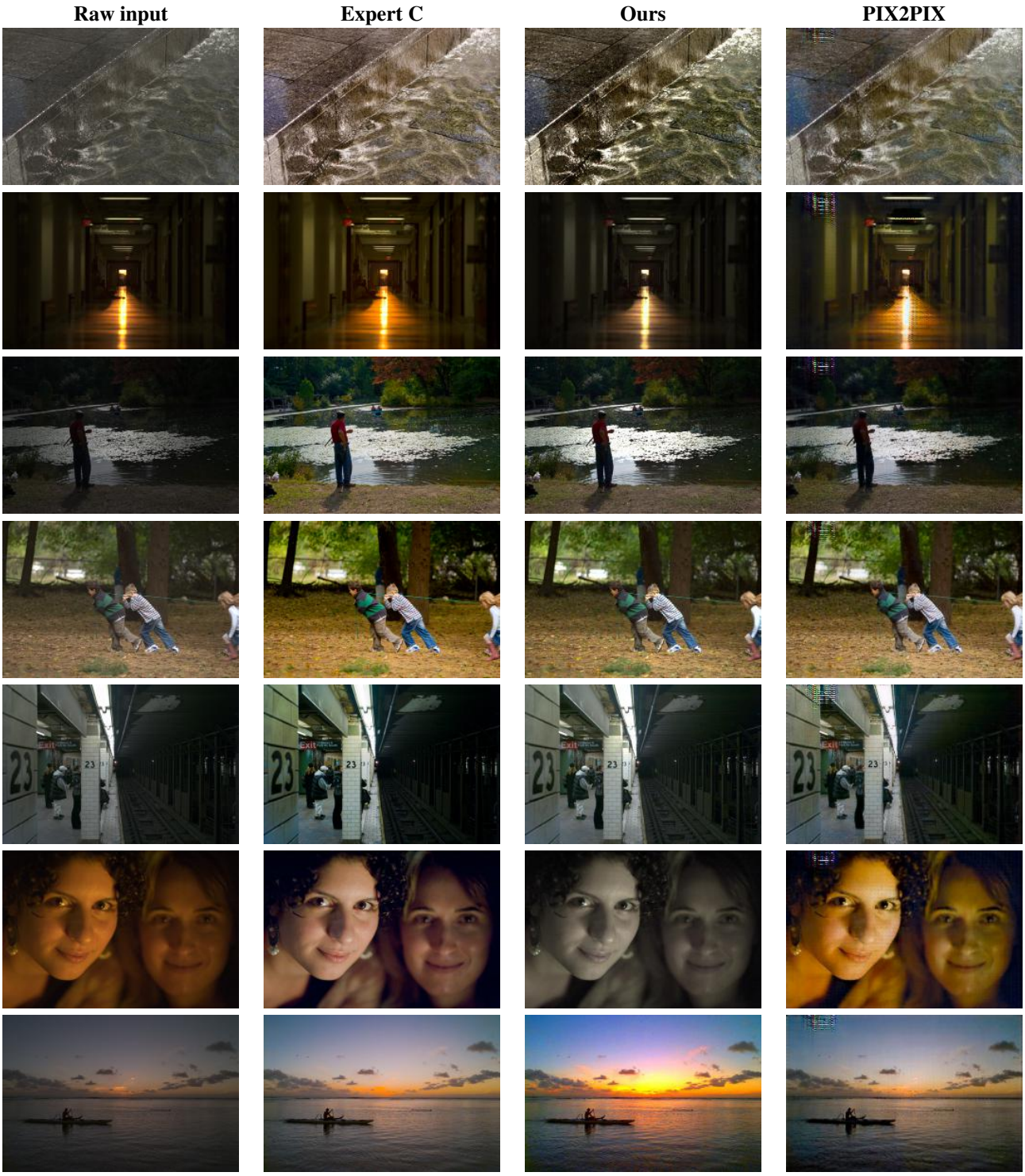


Table 191. [36 / 46] Experiment result using input-retouched image pairs

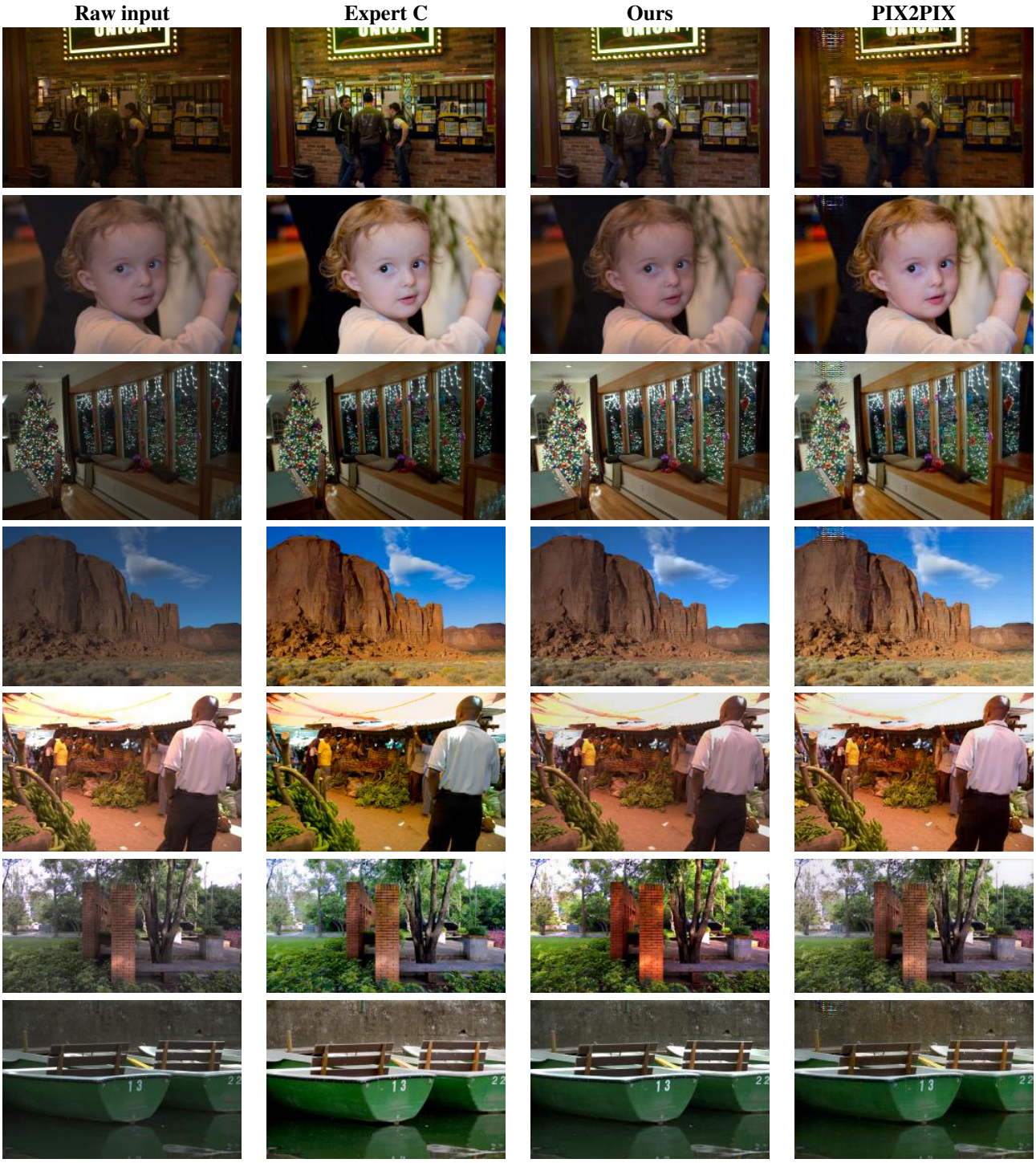


Table 192. [37 / 46] Experiment result using input-retouched image pairs

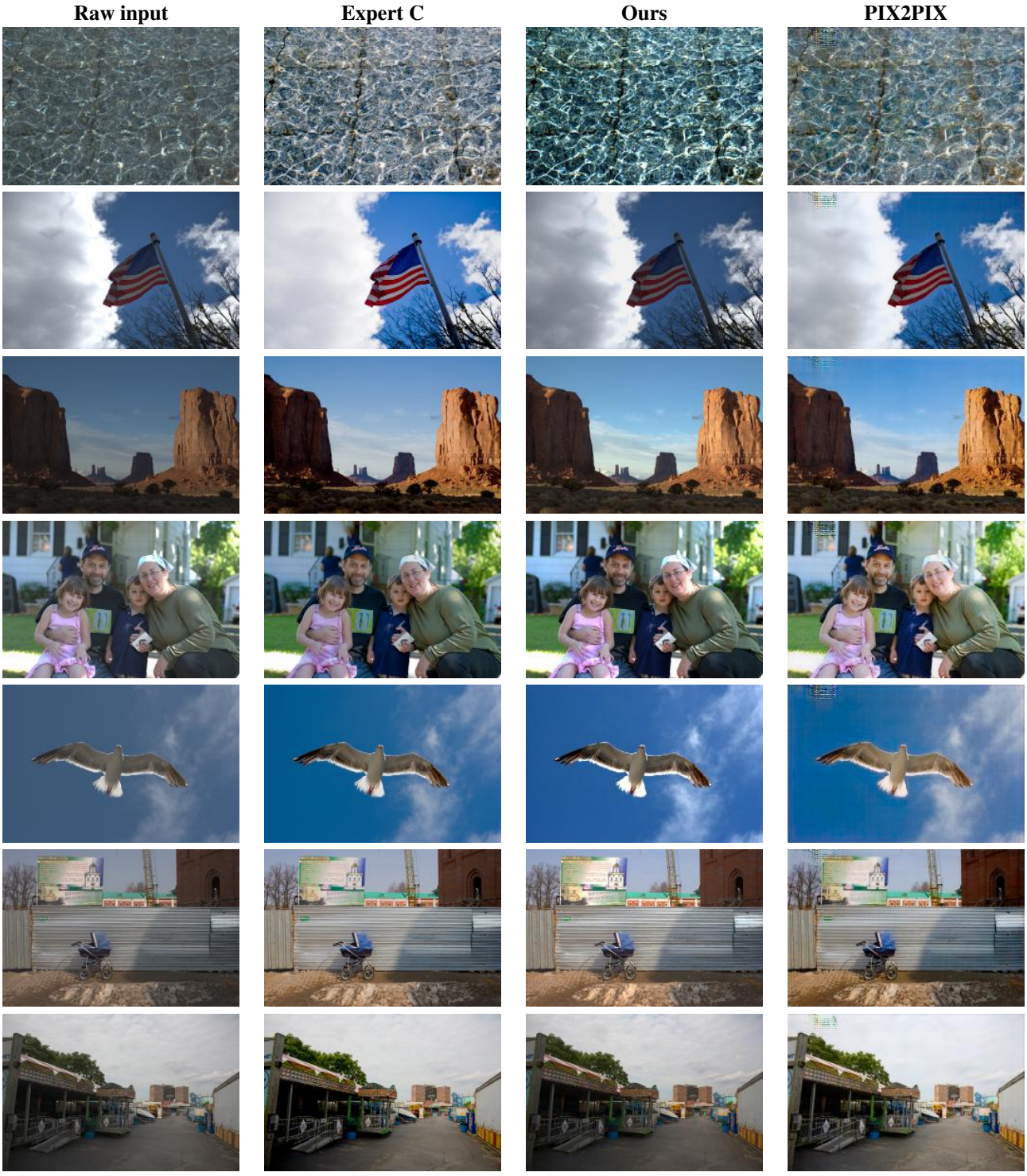


Table 193. [38 / 46] Experiment result using input-retouched image pairs

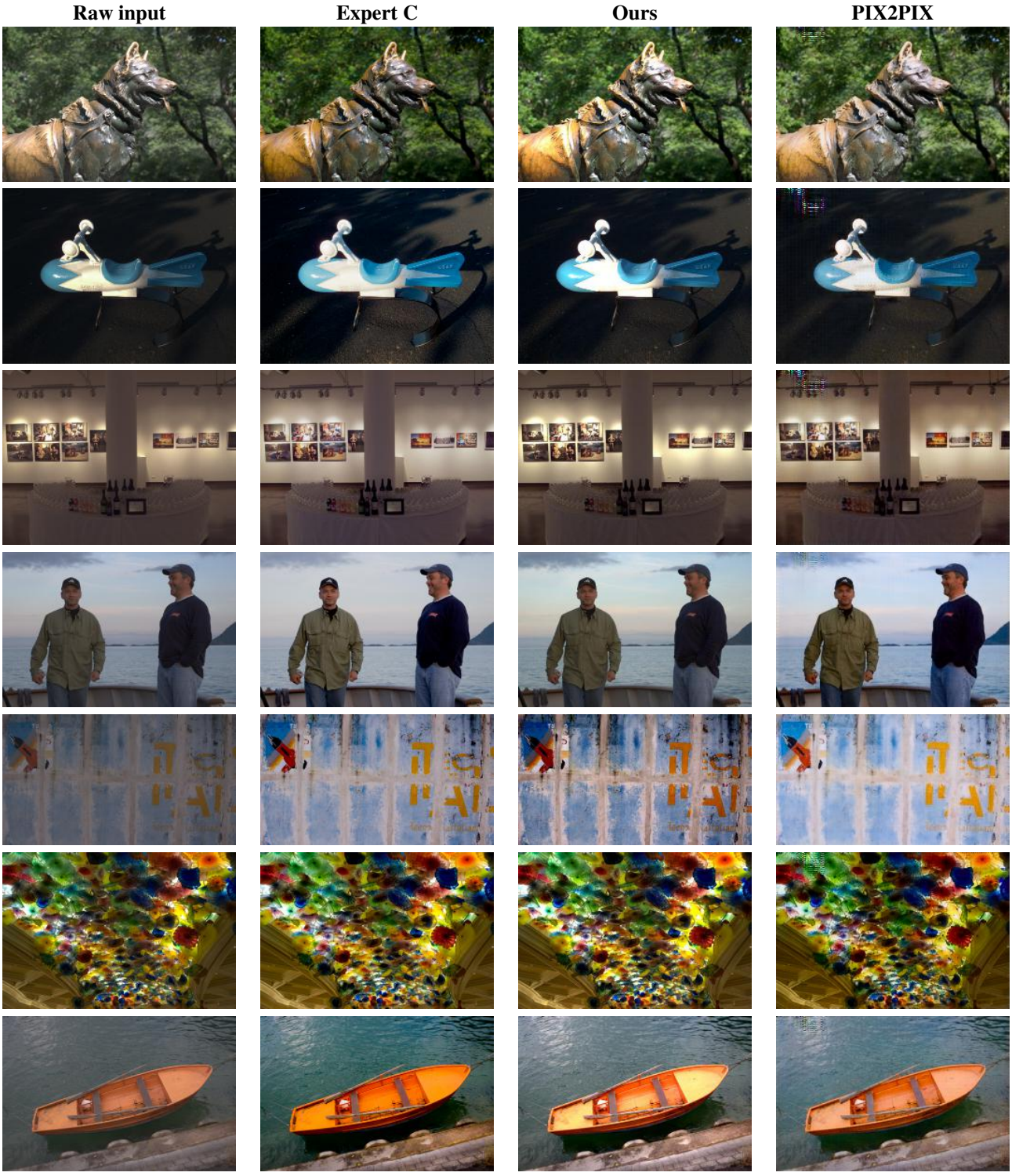


Table 194. [39 / 46] Experiment result using input-retouched image pairs

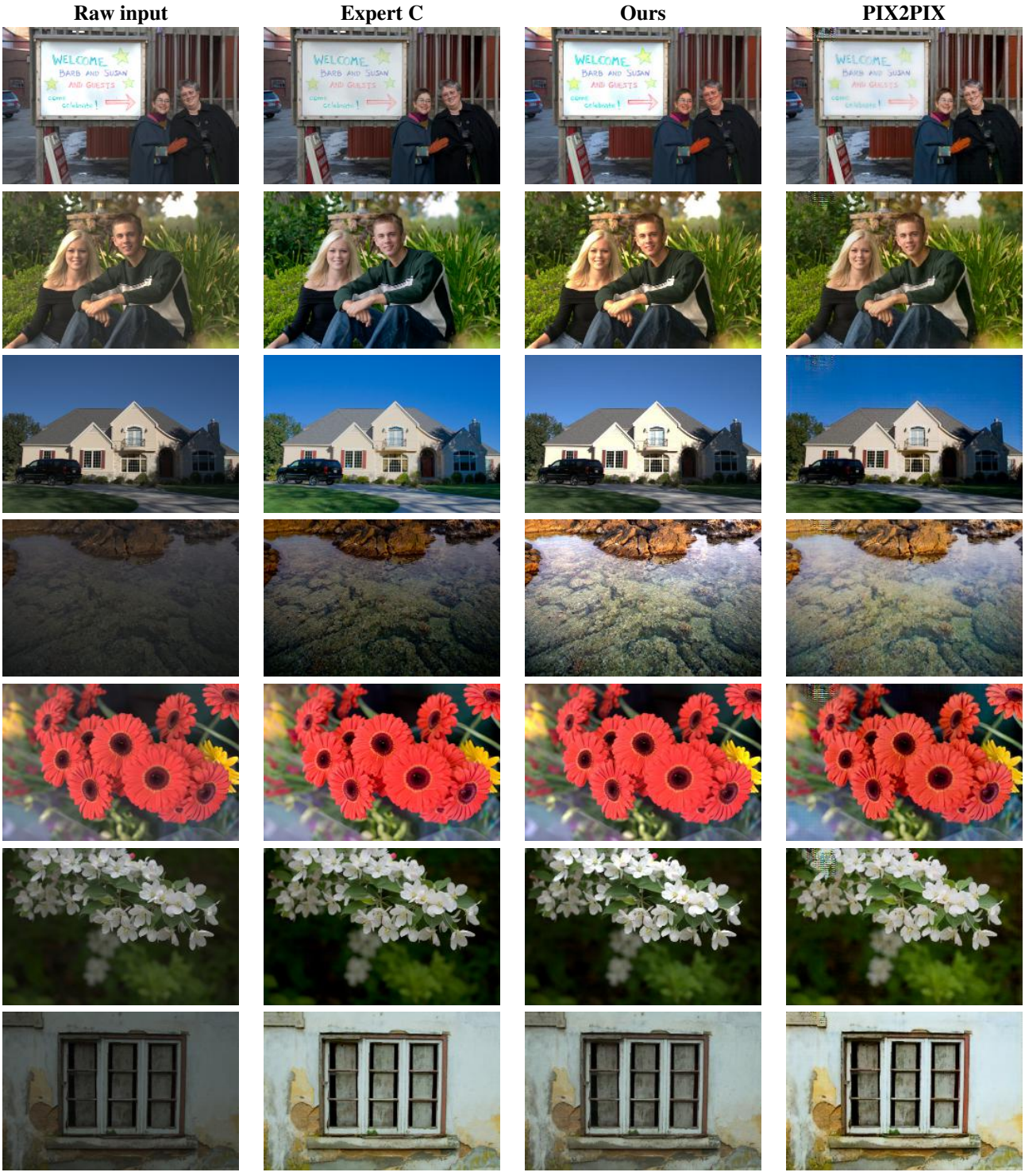


Table 195. [40 / 46] Experiment result using input-retouched image pairs

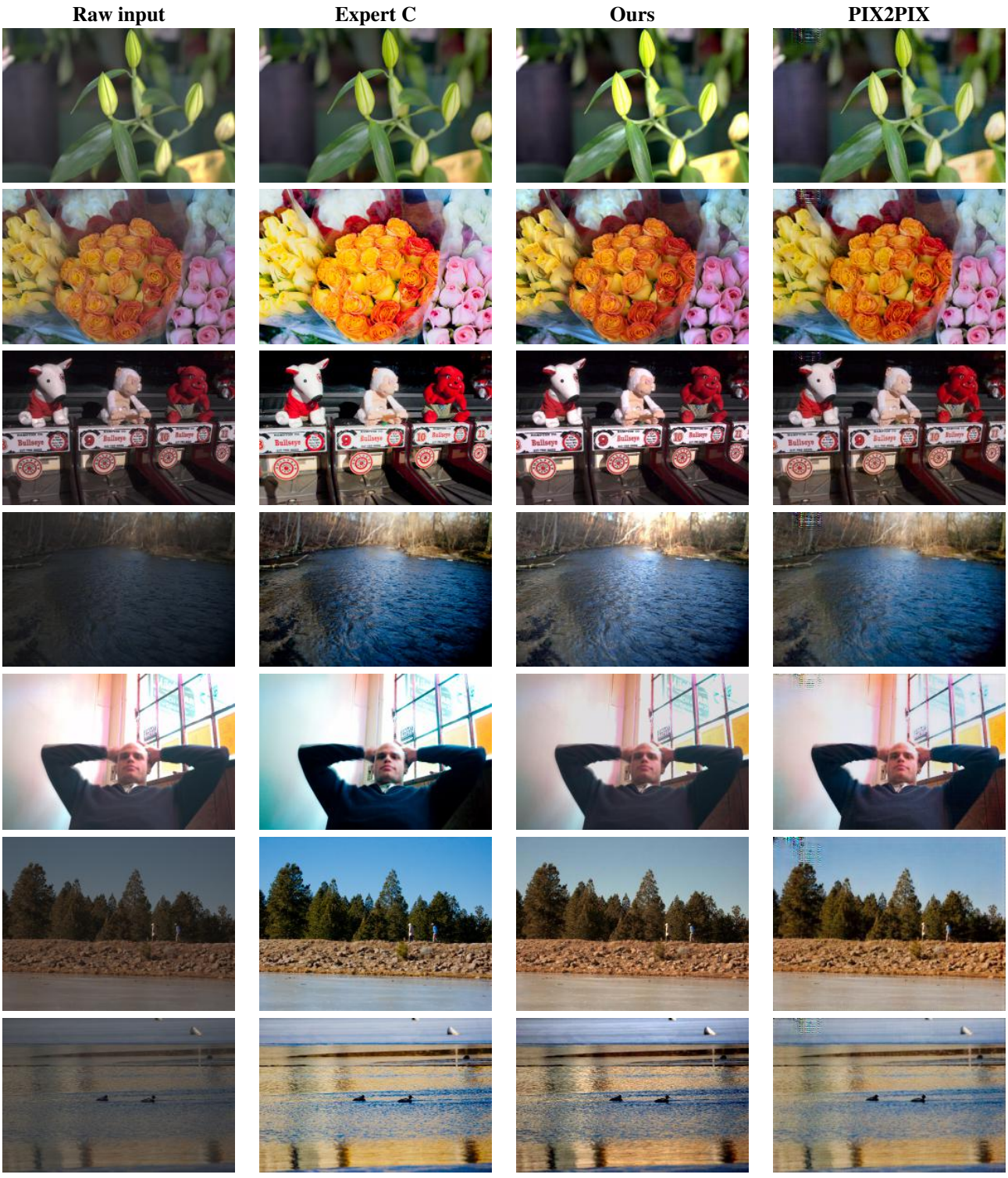


Table 196. [41 / 46] Experiment result using input-retouched image pairs

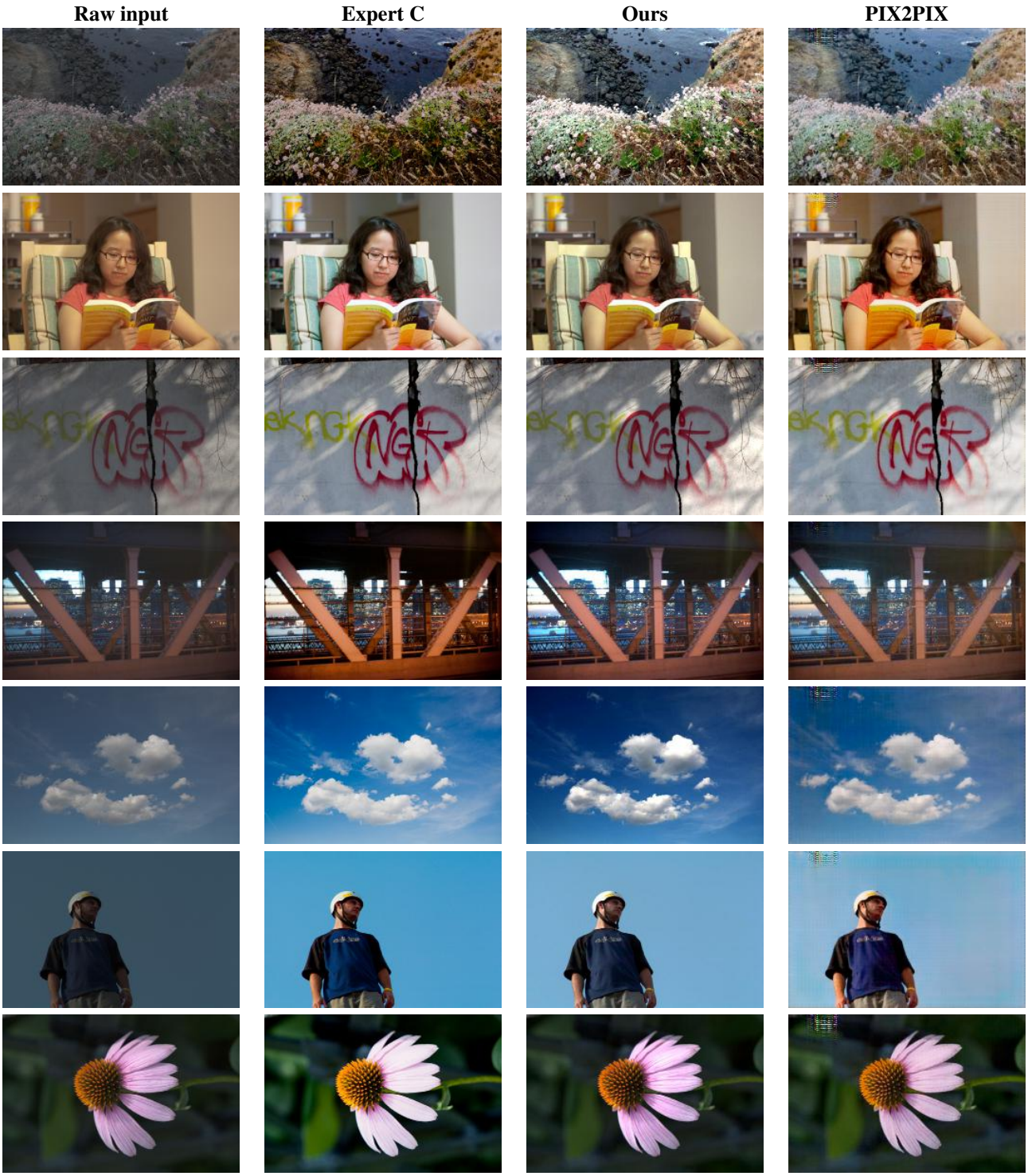


Table 197. [42 / 46] Experiment result using input-retouched image pairs

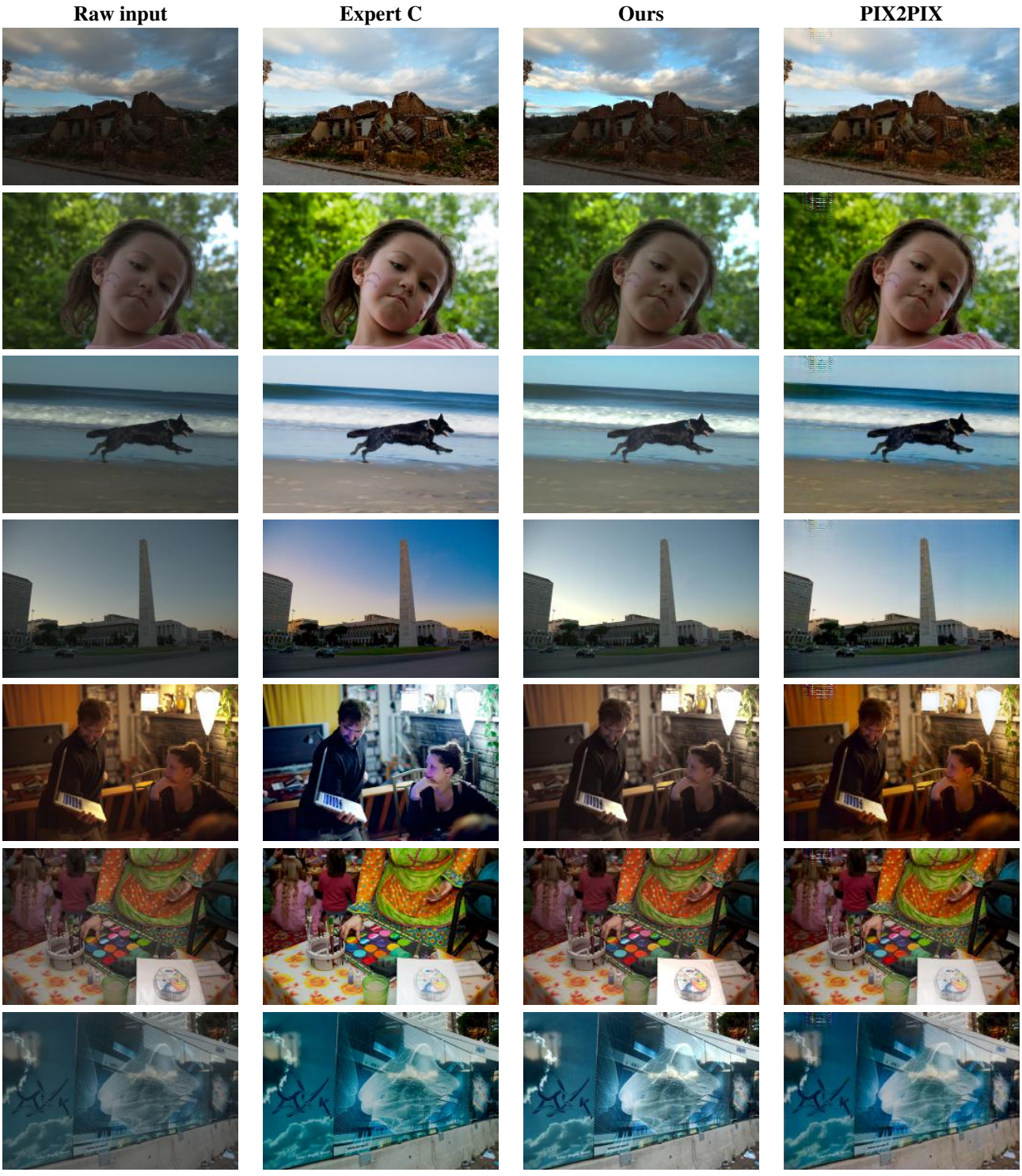


Table 198. [43 / 46] Experiment result using input-retouched image pairs

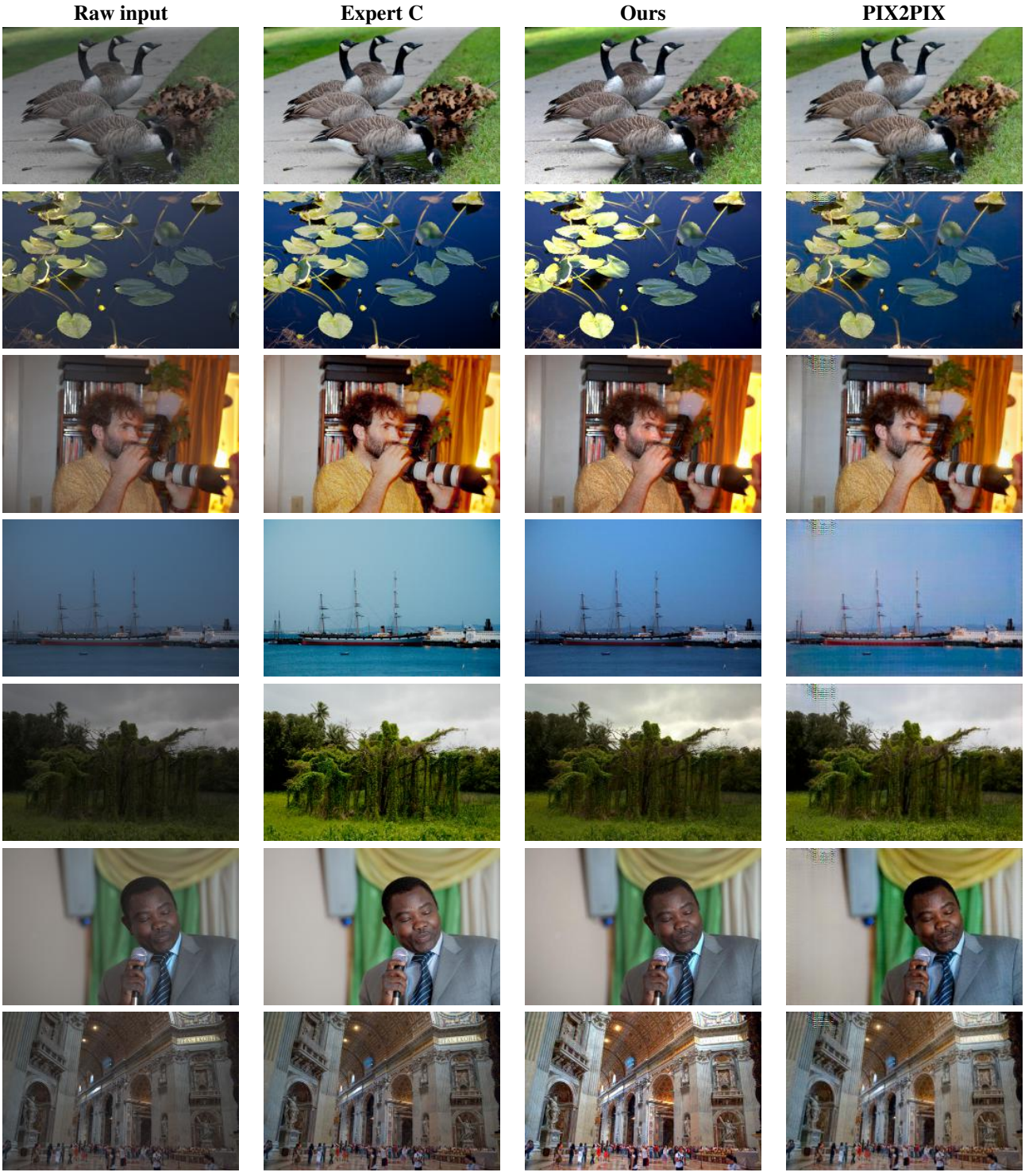


Table 199. [44 / 46] Experiment result using input-retouched image pairs

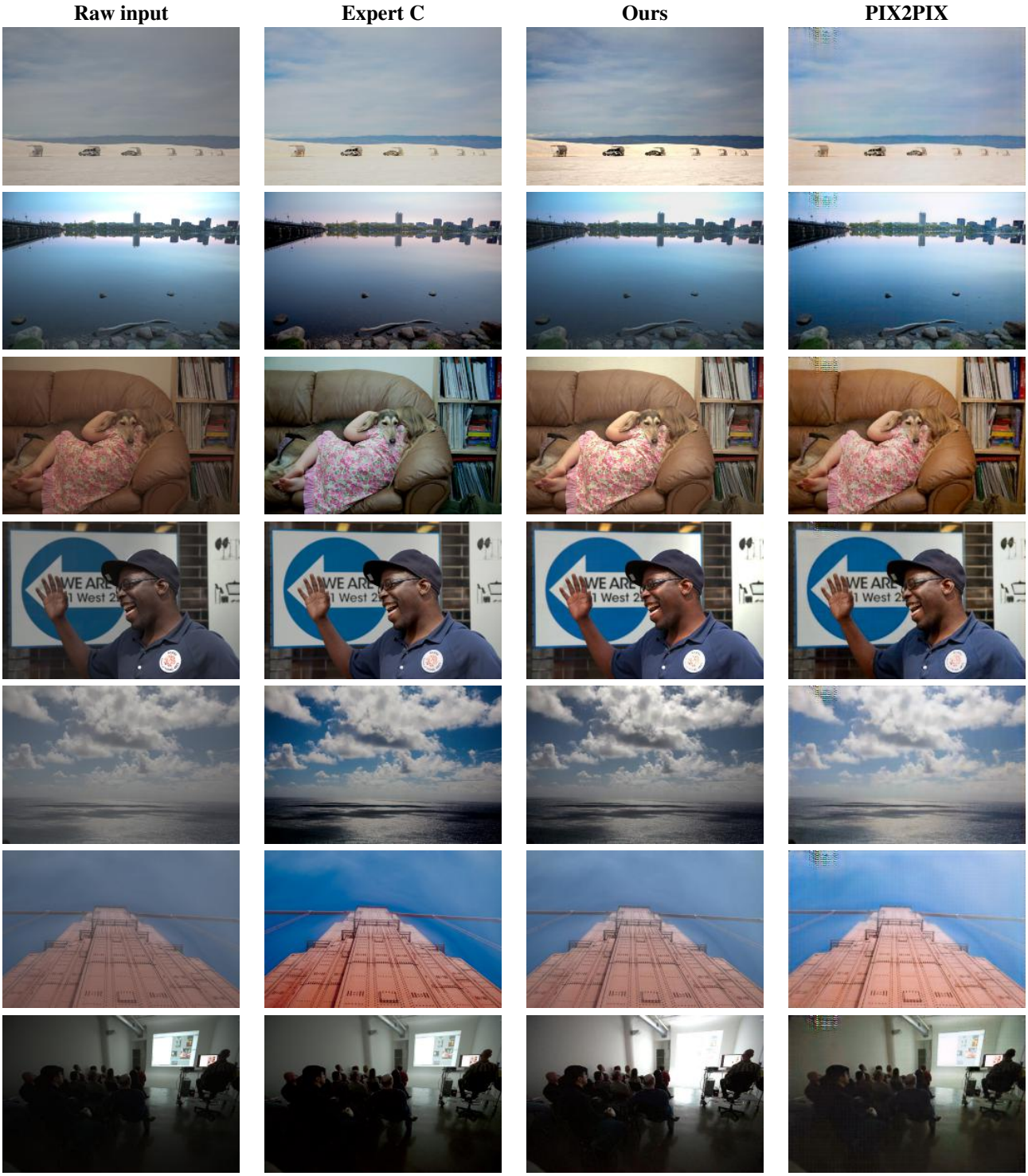


Table 200. [45 / 46] Experiment result using input-retouched image pairs

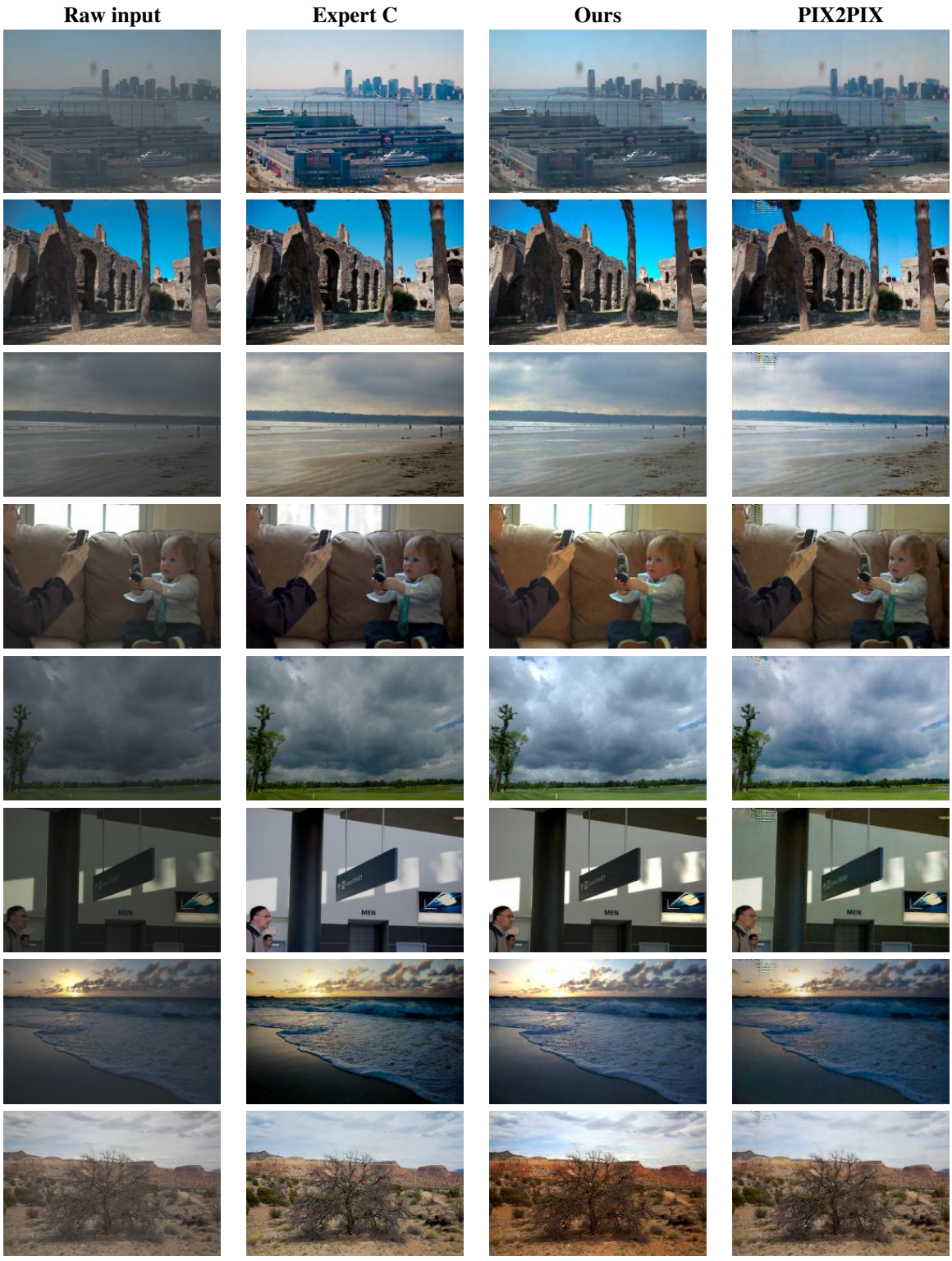


Table 201. [46 / 46] Experiment result using input-retouched image pairs

4.5. Experiment result using *distort-and-recover* training scheme on Shutterstock 150K images. (compared with Pix2Pix baseline)

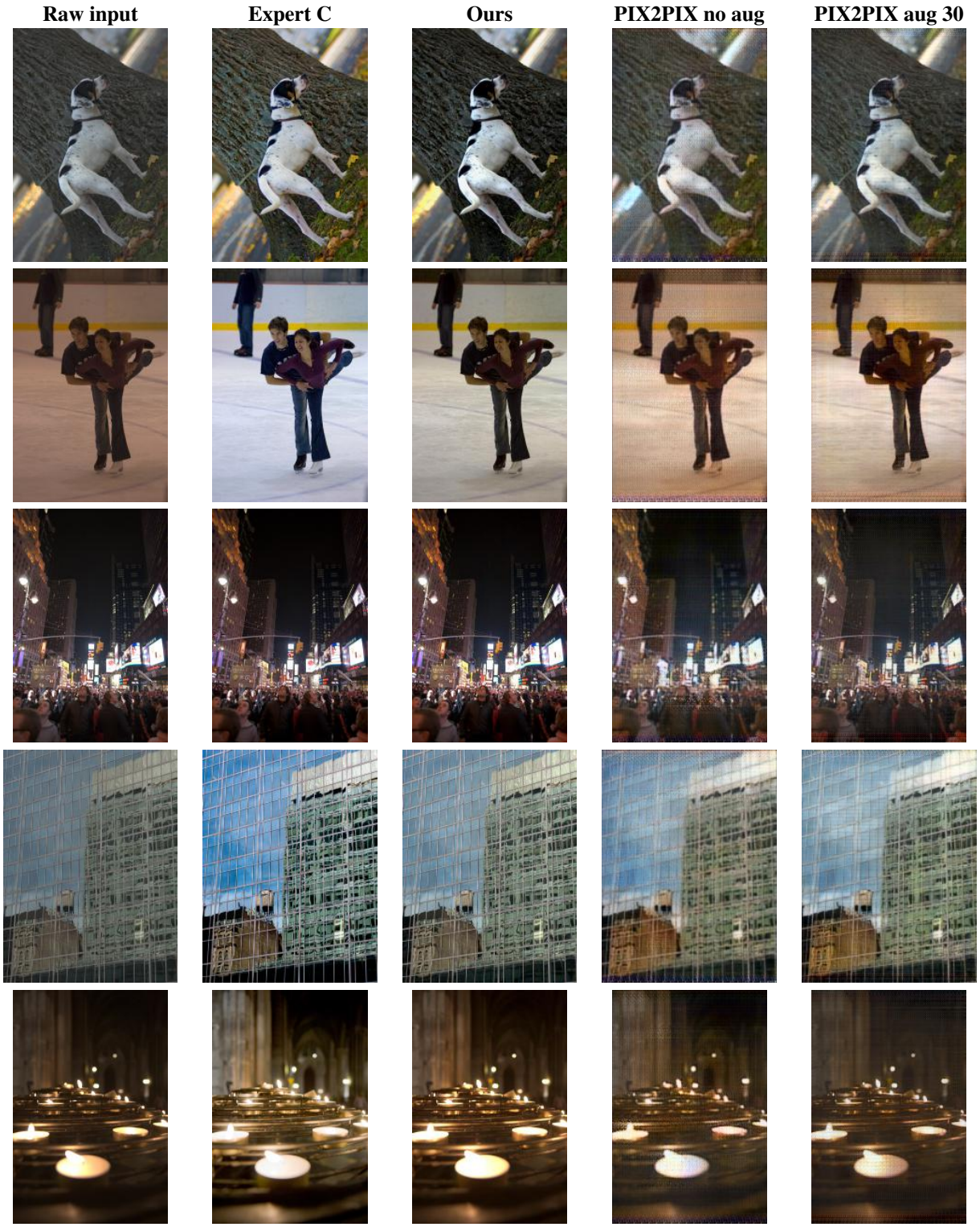


Table 202. [1 / 37] Experiment results using distort-and-recover scheme

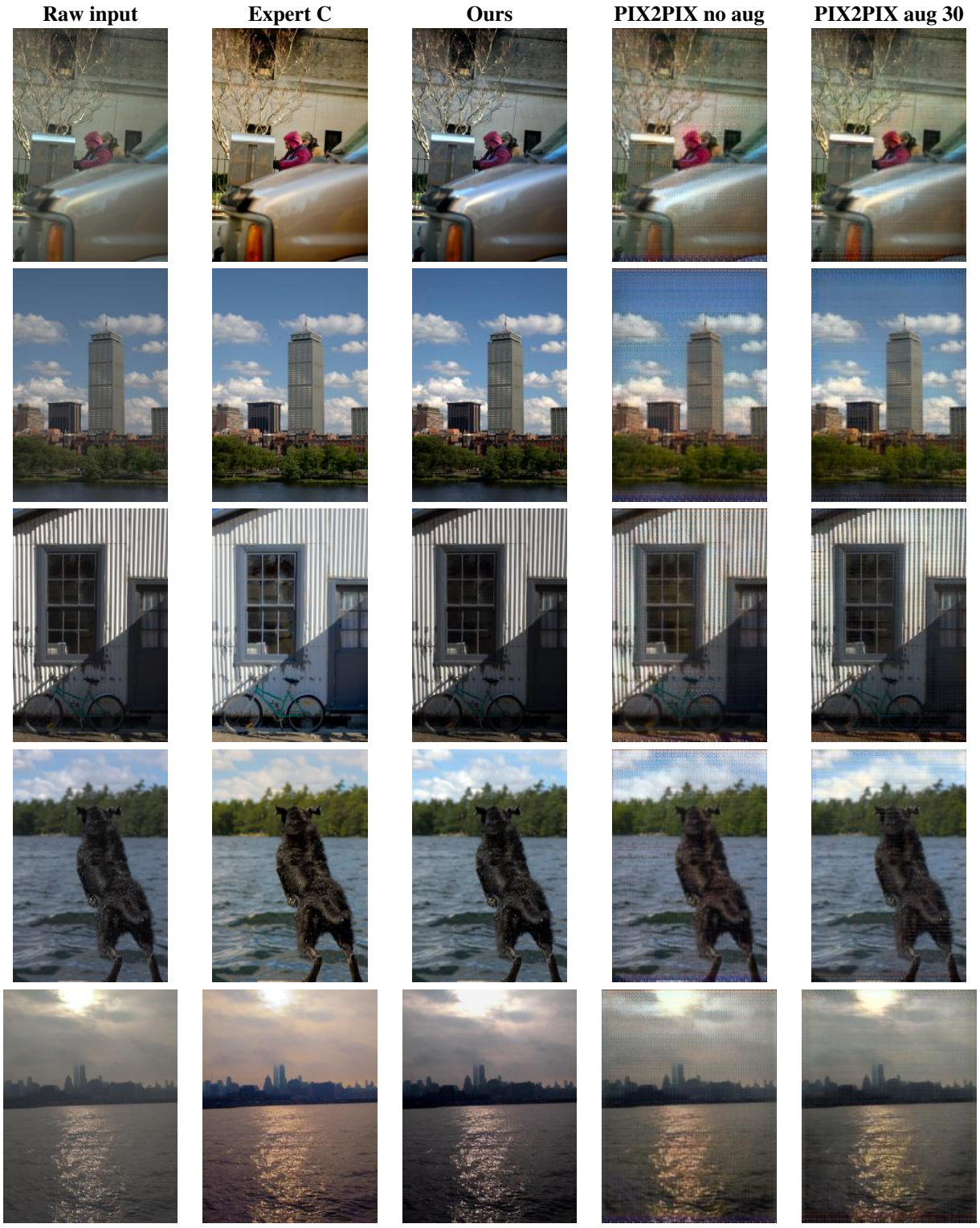


Table 203. [2 / 37] Experiment results using distort-and-recover scheme

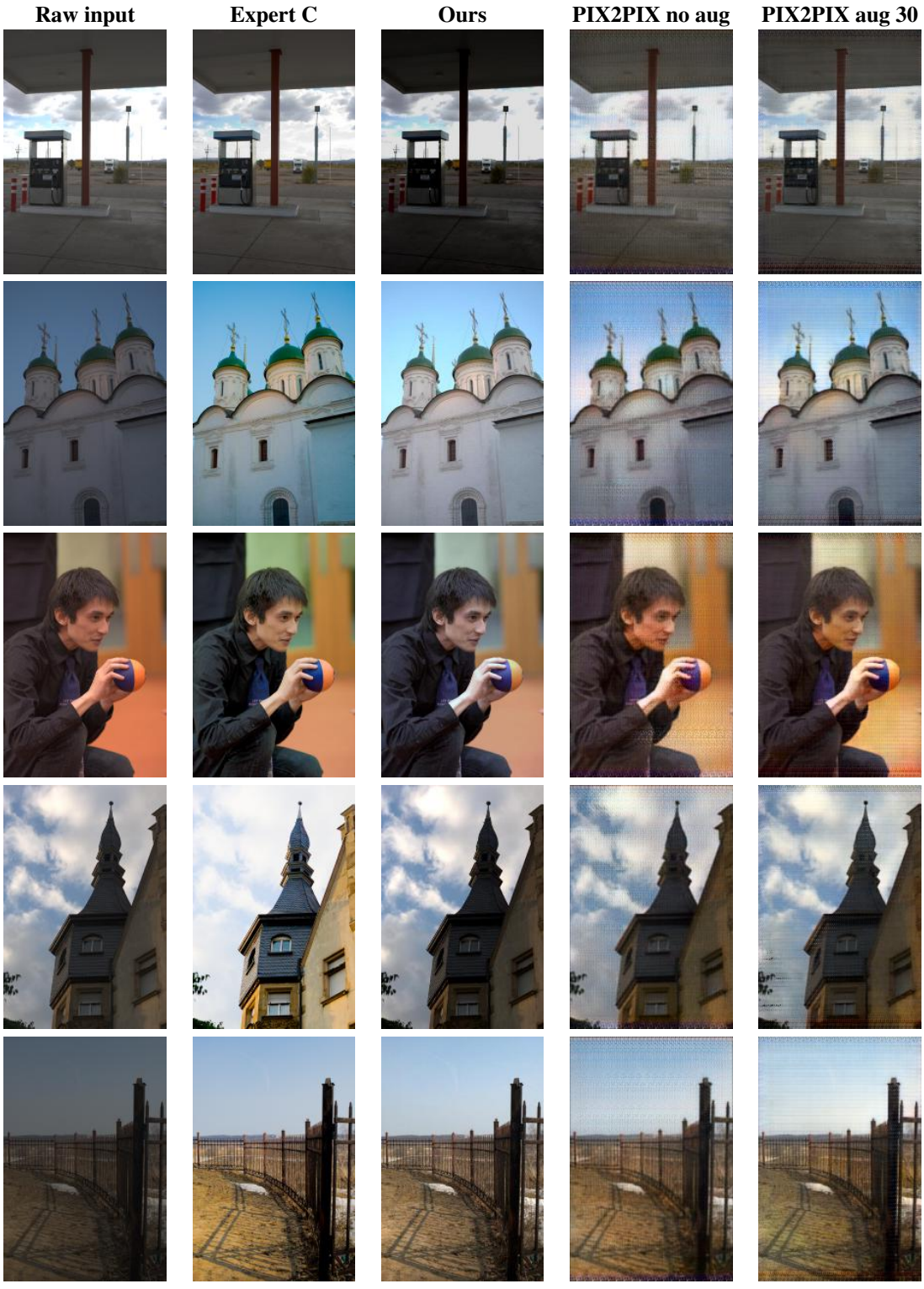


Table 204. [3 / 37] Experiment results using distort-and-recover scheme

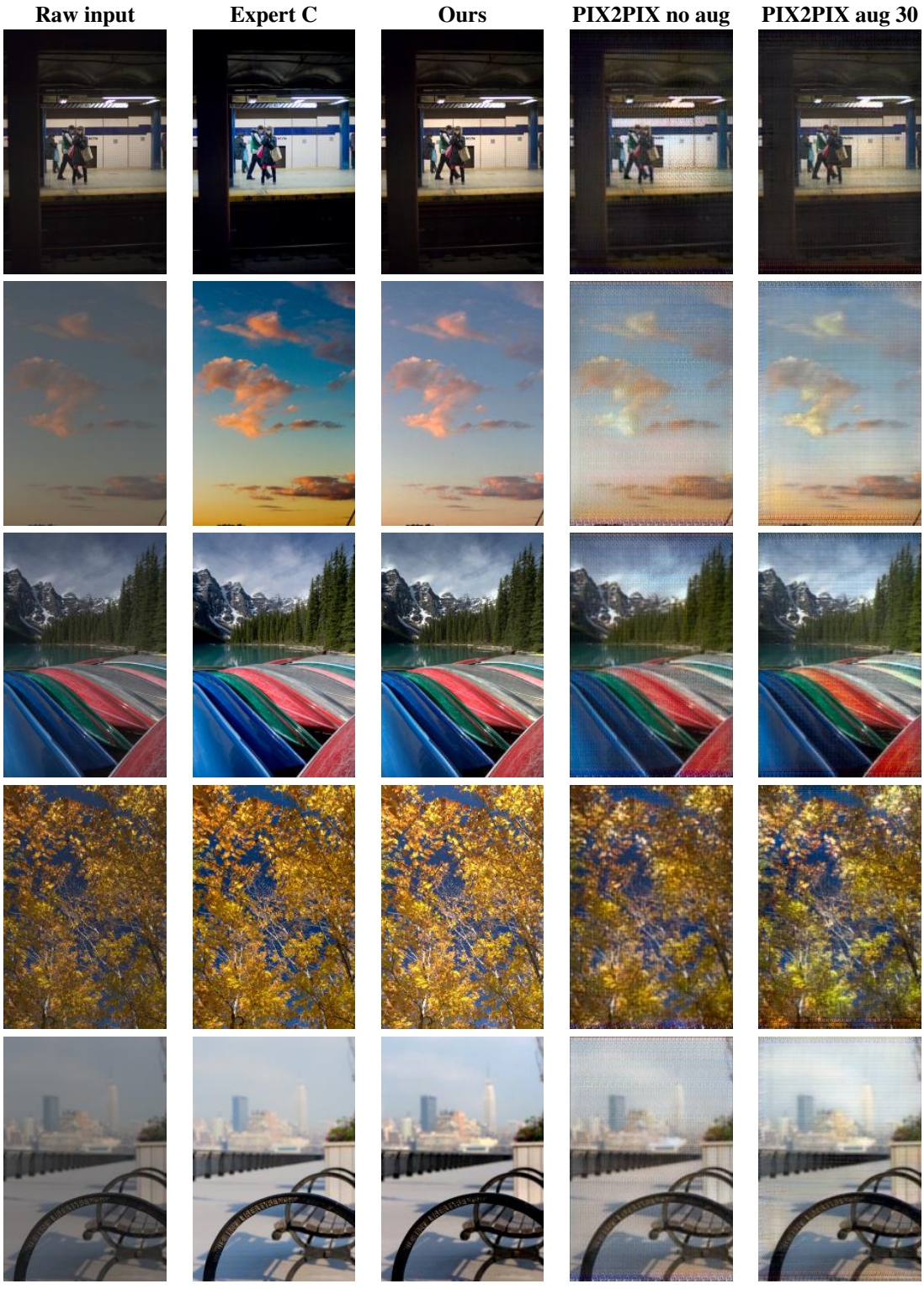


Table 205. [4 / 37] Experiment results using distort-and-recover scheme

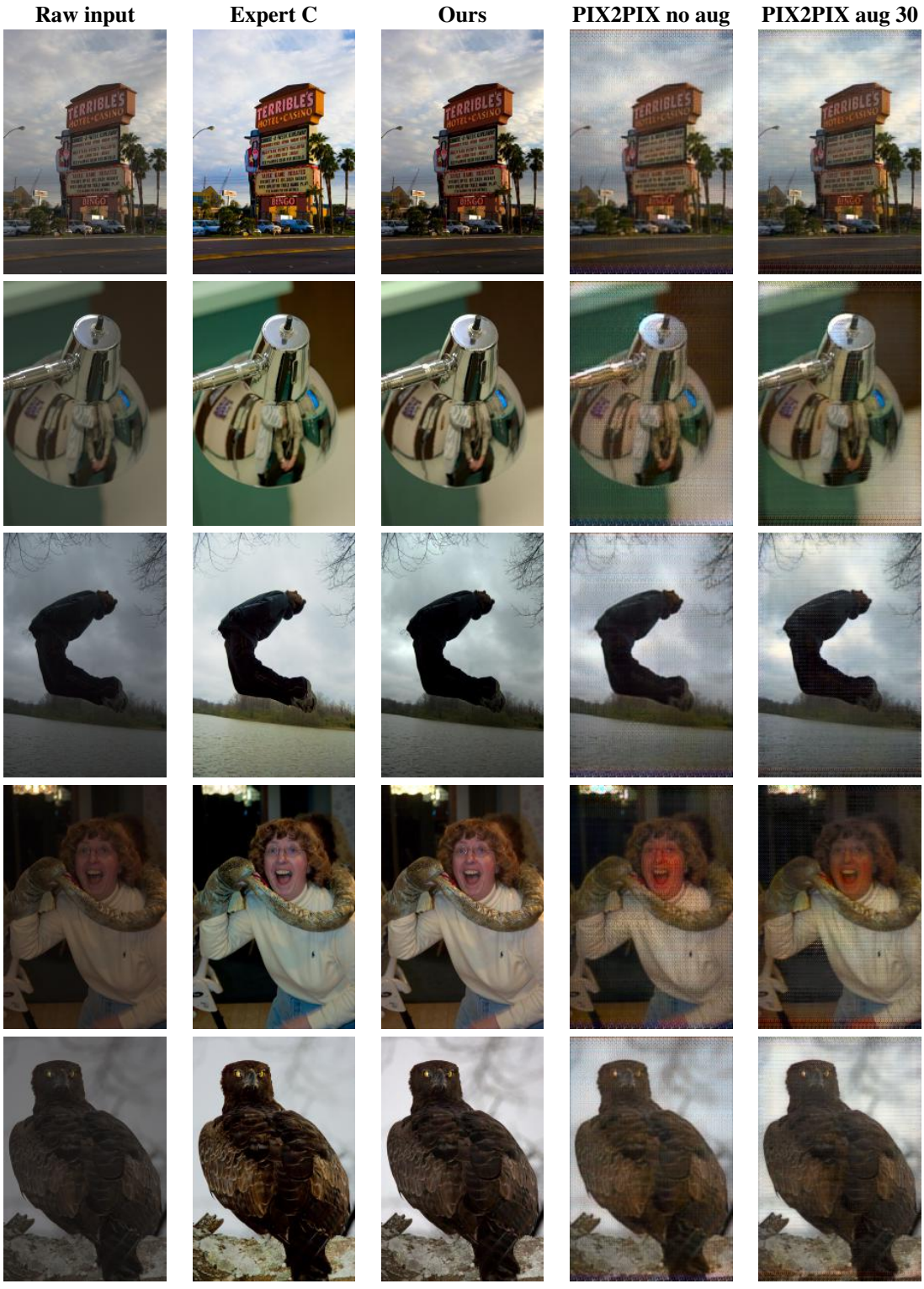


Table 206. [5 / 37] Experiment results using distort-and-recover scheme

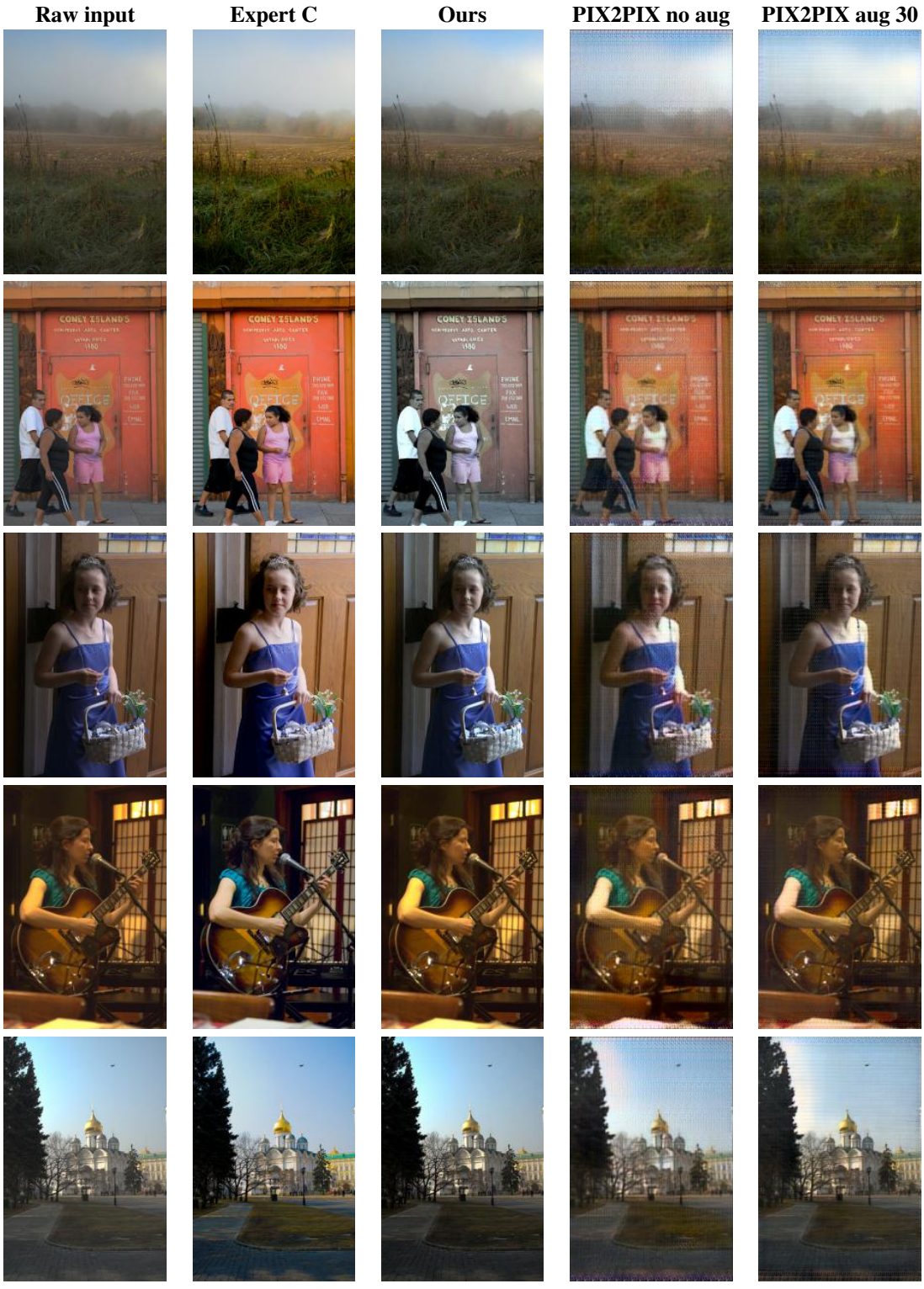


Table 207. [6 / 37] Experiment results using distort-and-recover scheme

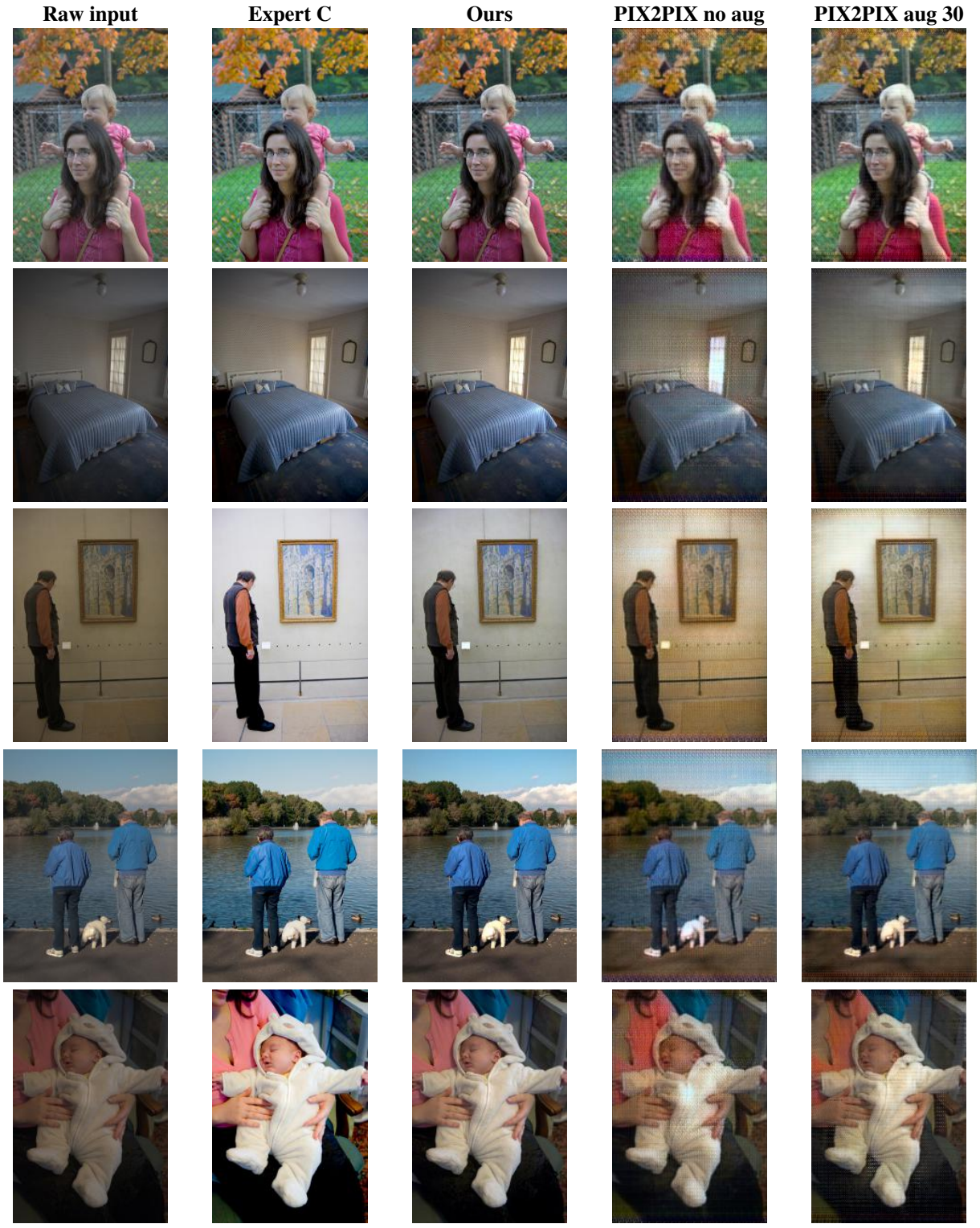


Table 208. [7 / 37] Experiment results using distort-and-recover scheme

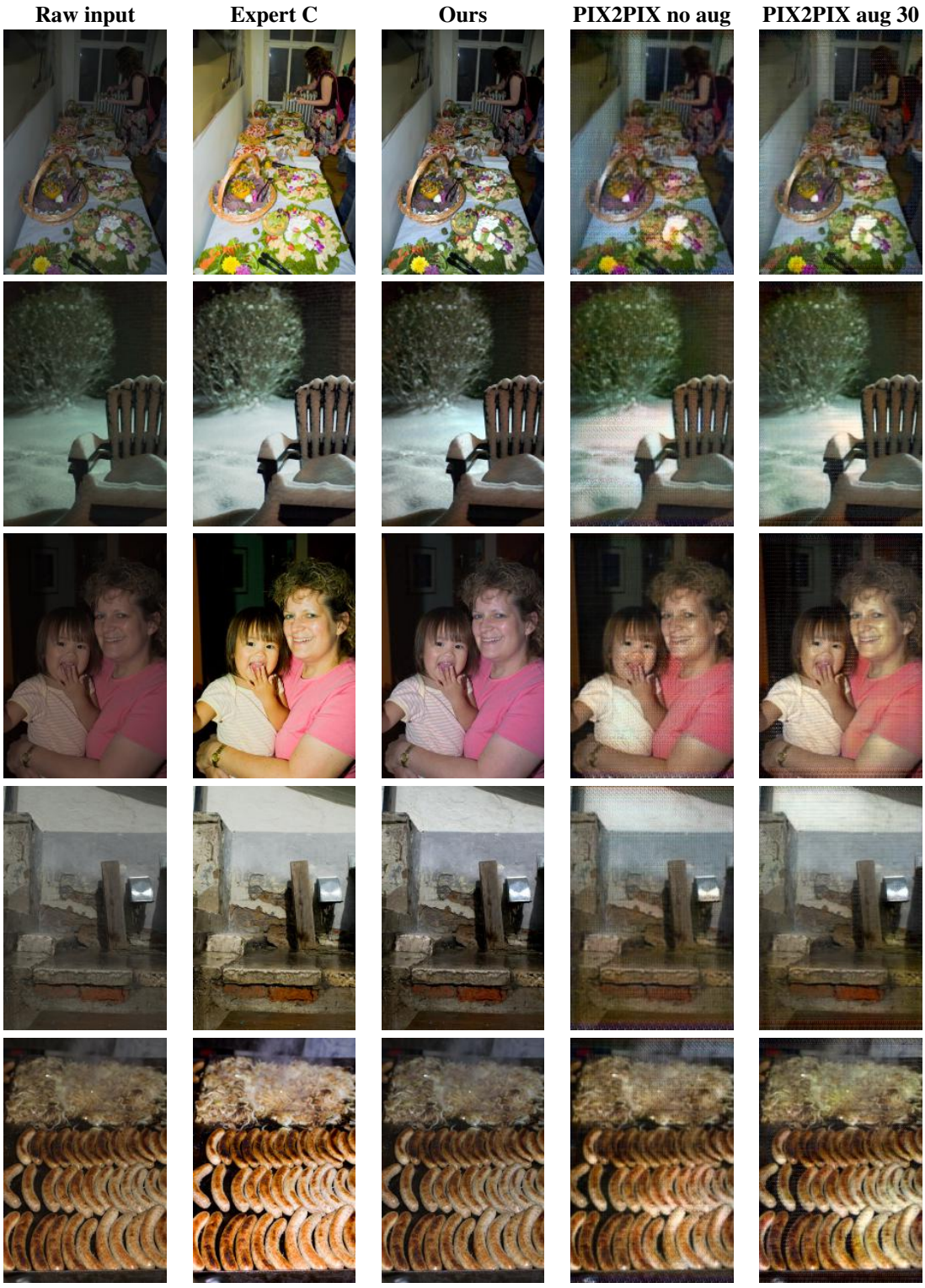


Table 209. [8 / 37] Experiment results using distort-and-recover scheme

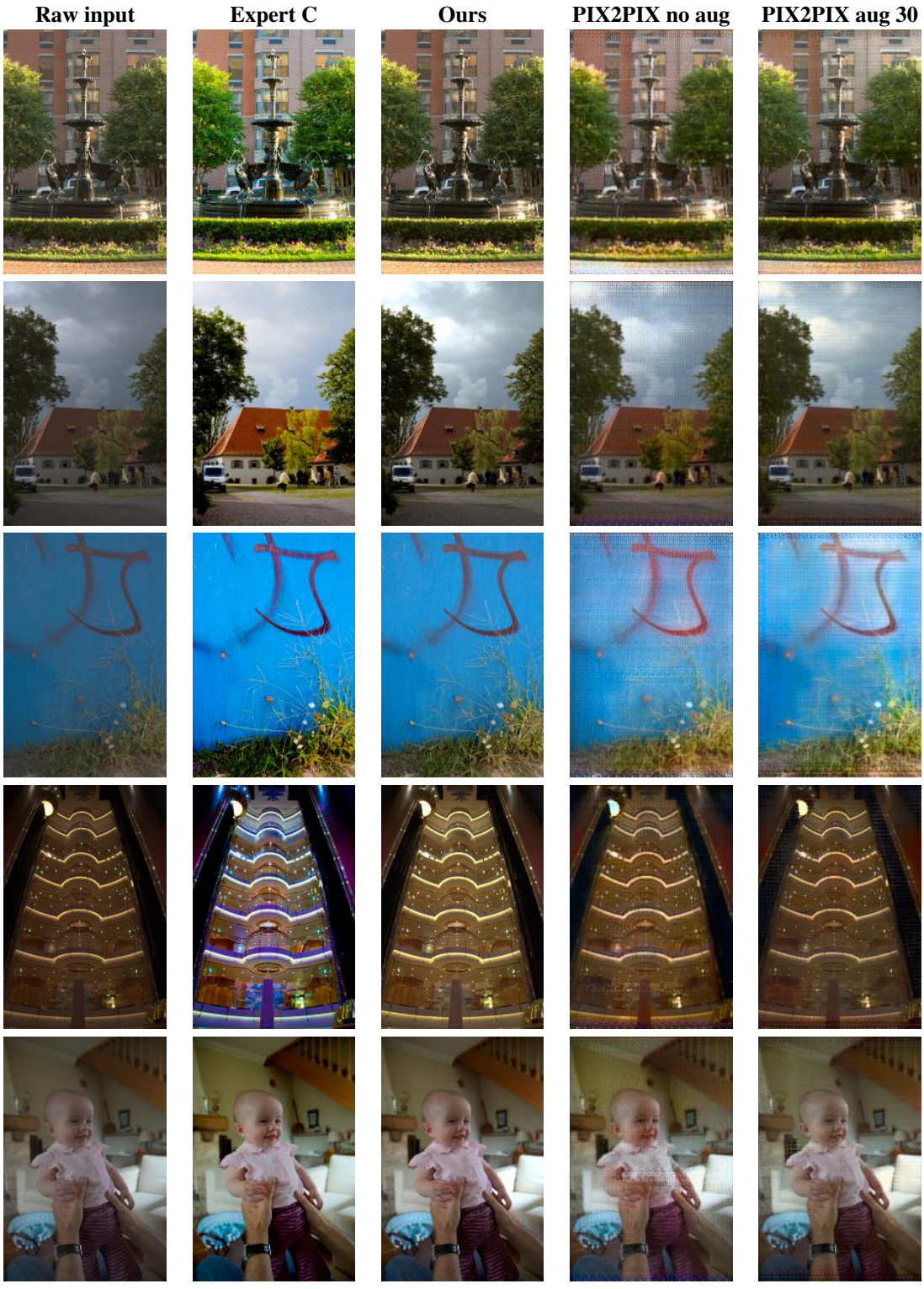


Table 210. [9 / 37] Experiment results using distort-and-recover scheme

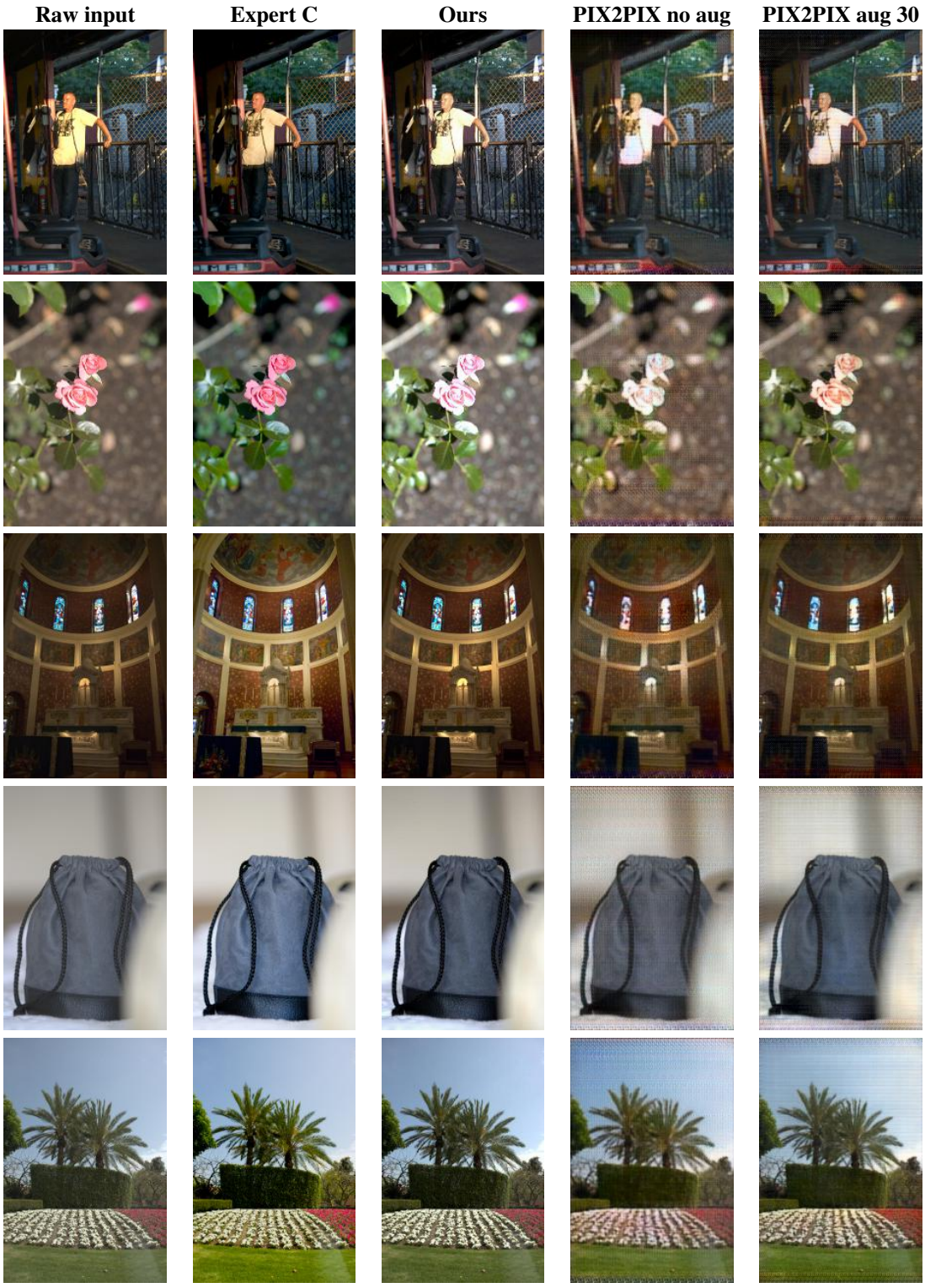


Table 211. [10 / 37] Experiment results using distort-and-recover scheme

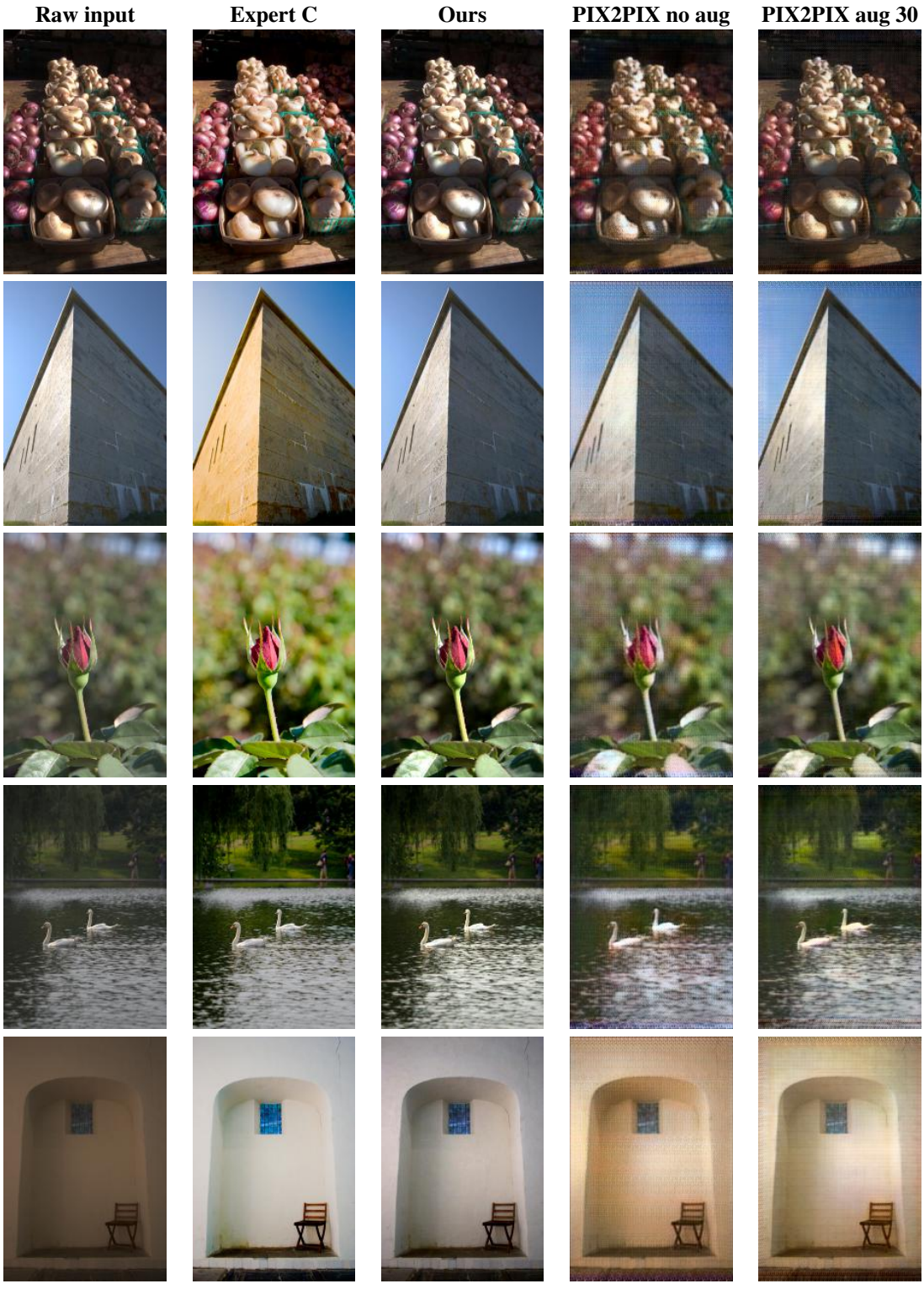


Table 212. [11 / 37] Experiment results using distort-and-recover scheme

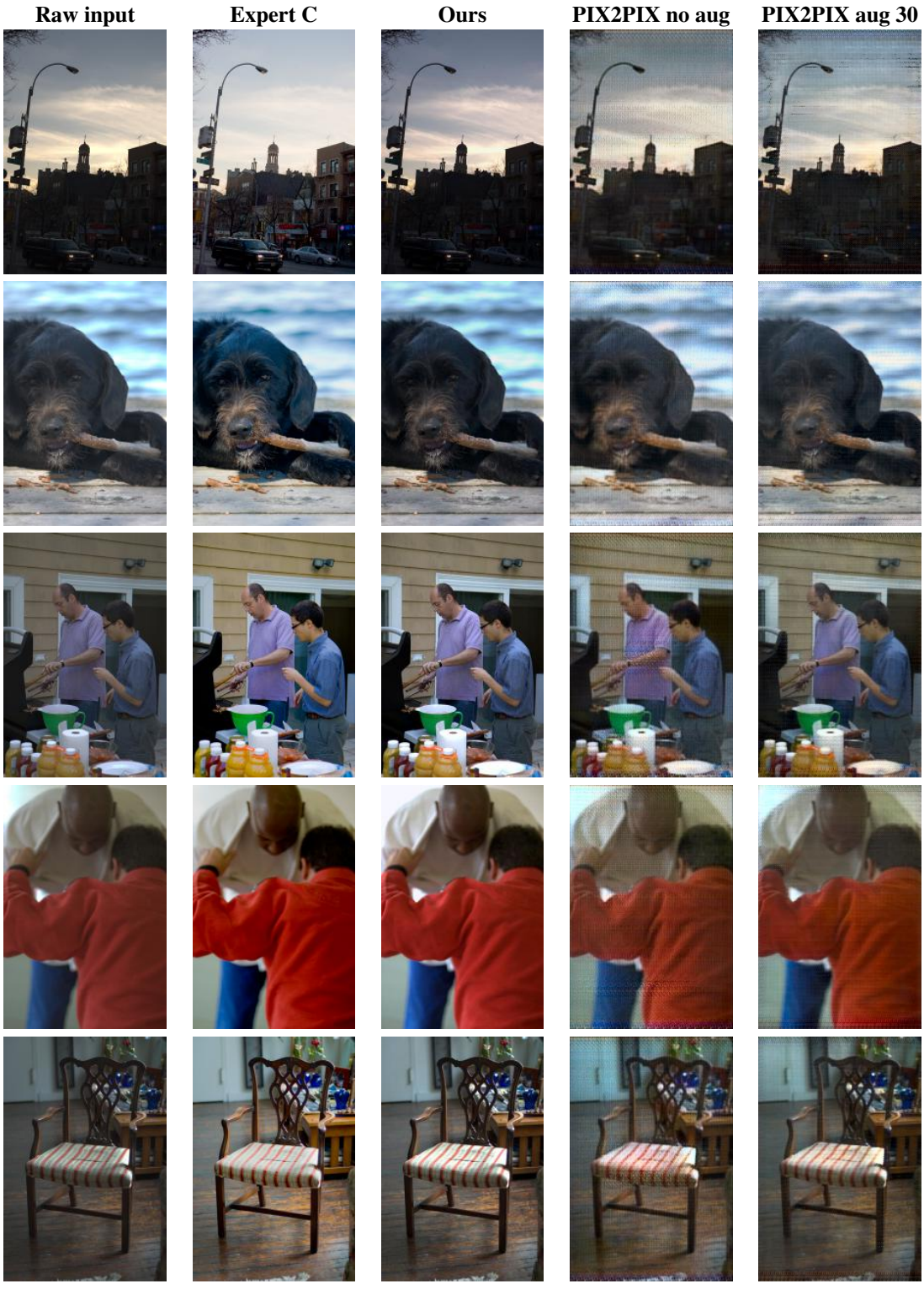


Table 213. [12 / 37] Experiment results using distort-and-recover scheme

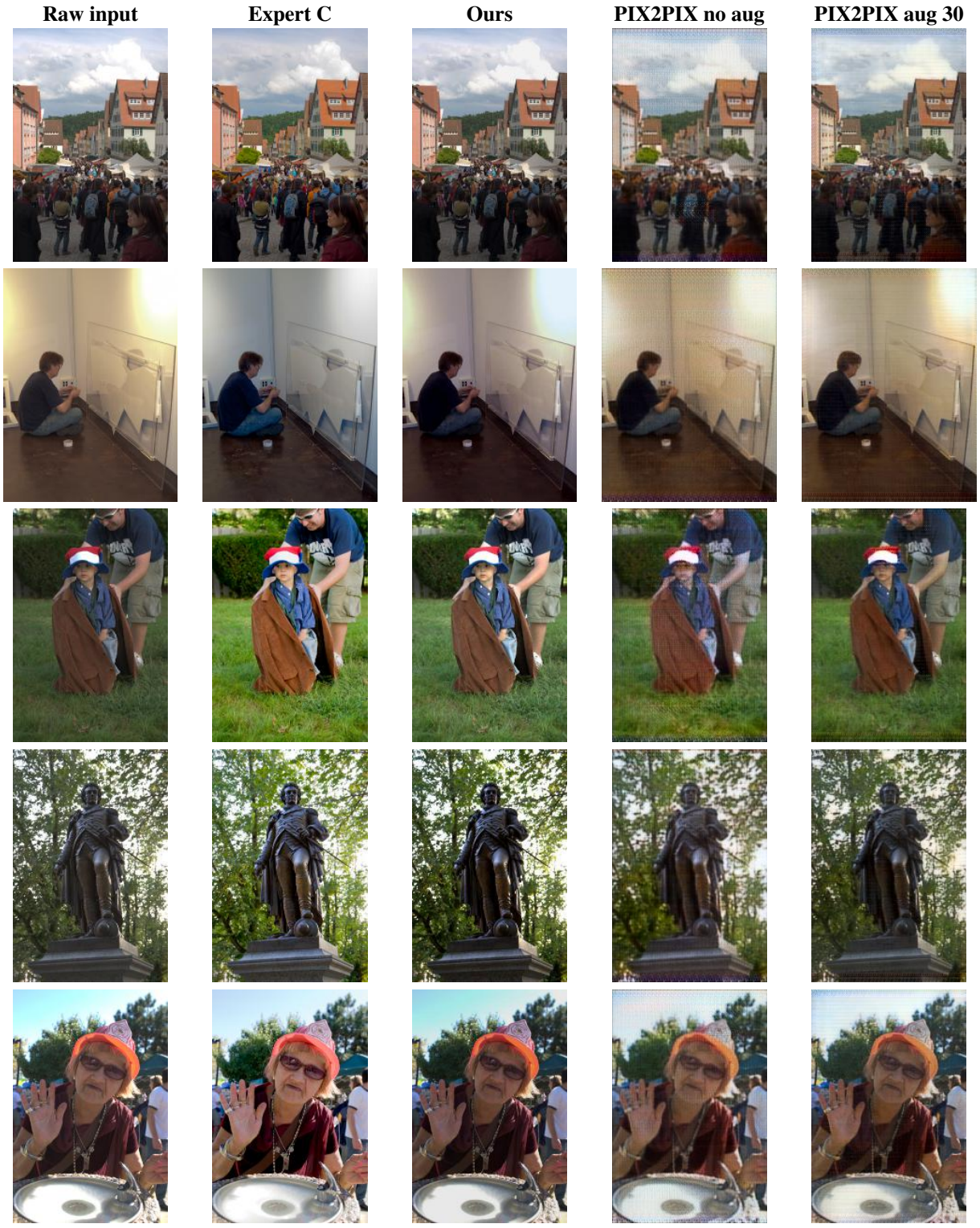


Table 214. [13 / 37] Experiment results using distort-and-recover scheme

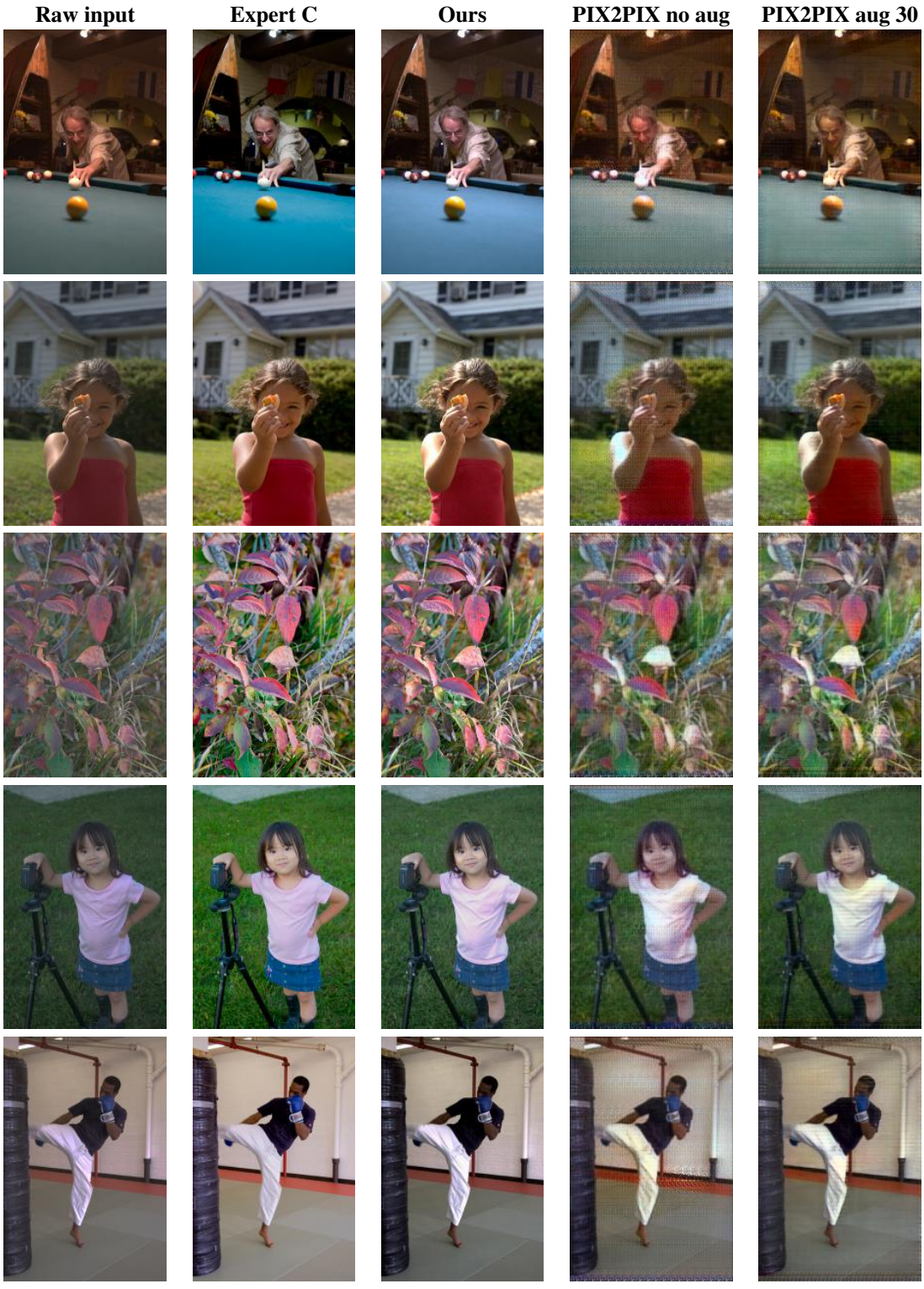


Table 215. [14 / 37] Experiment results using distort-and-recover scheme

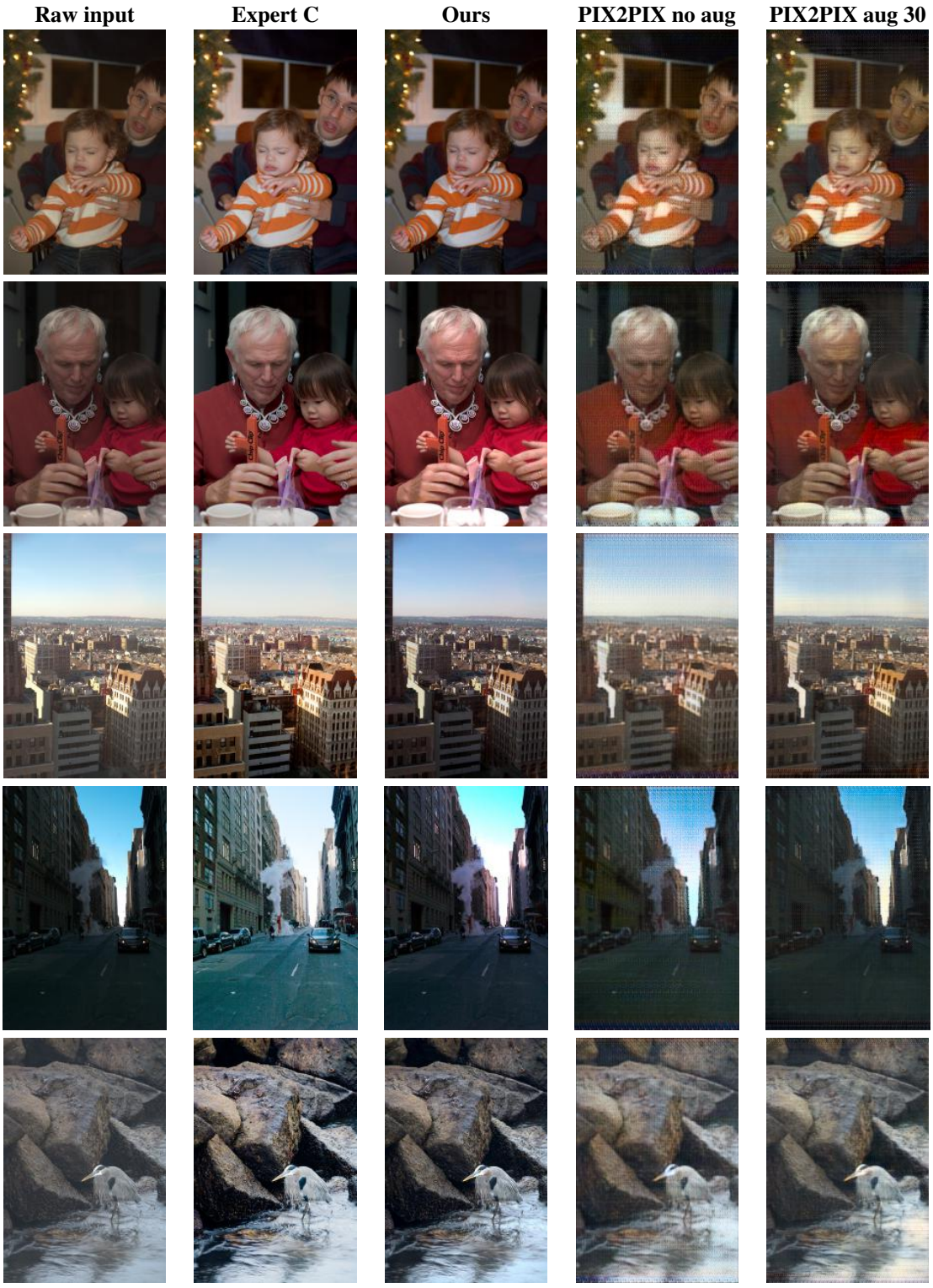


Table 216. [15 / 37] Experiment results using distort-and-recover scheme

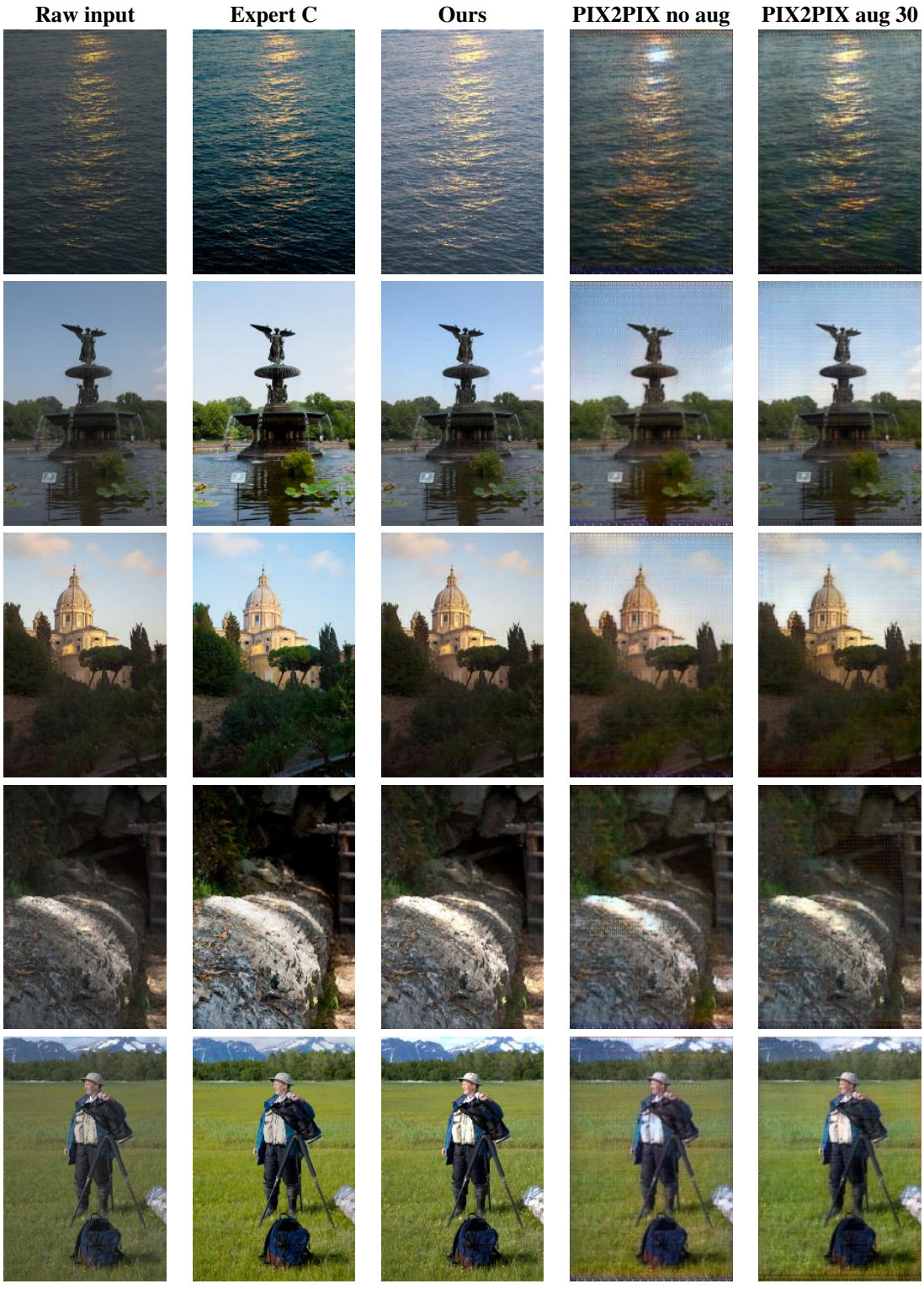


Table 217. [16 / 37] Experiment results using distort-and-recover scheme

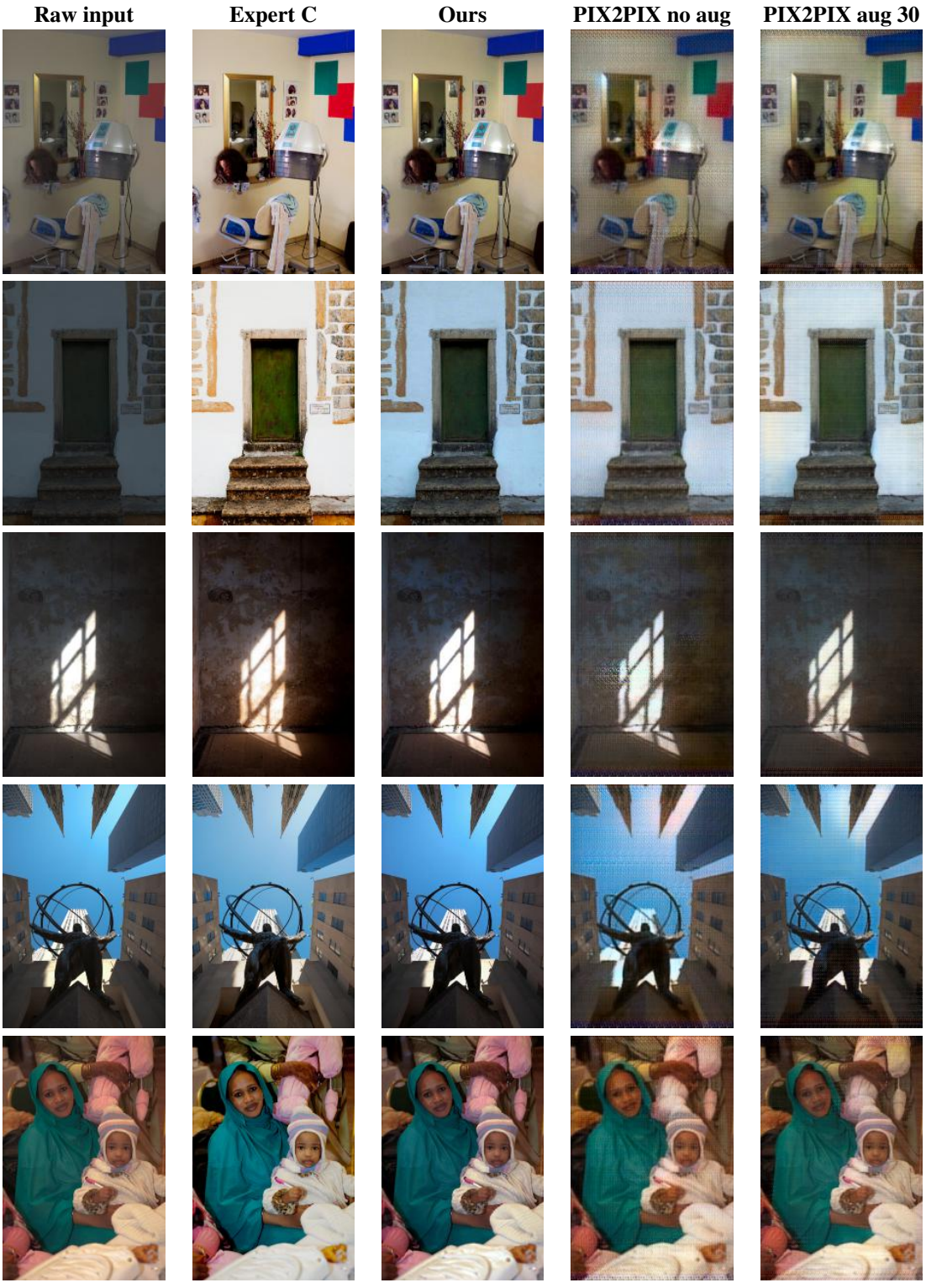


Table 218. [17 / 37] Experiment results using distort-and-recover scheme

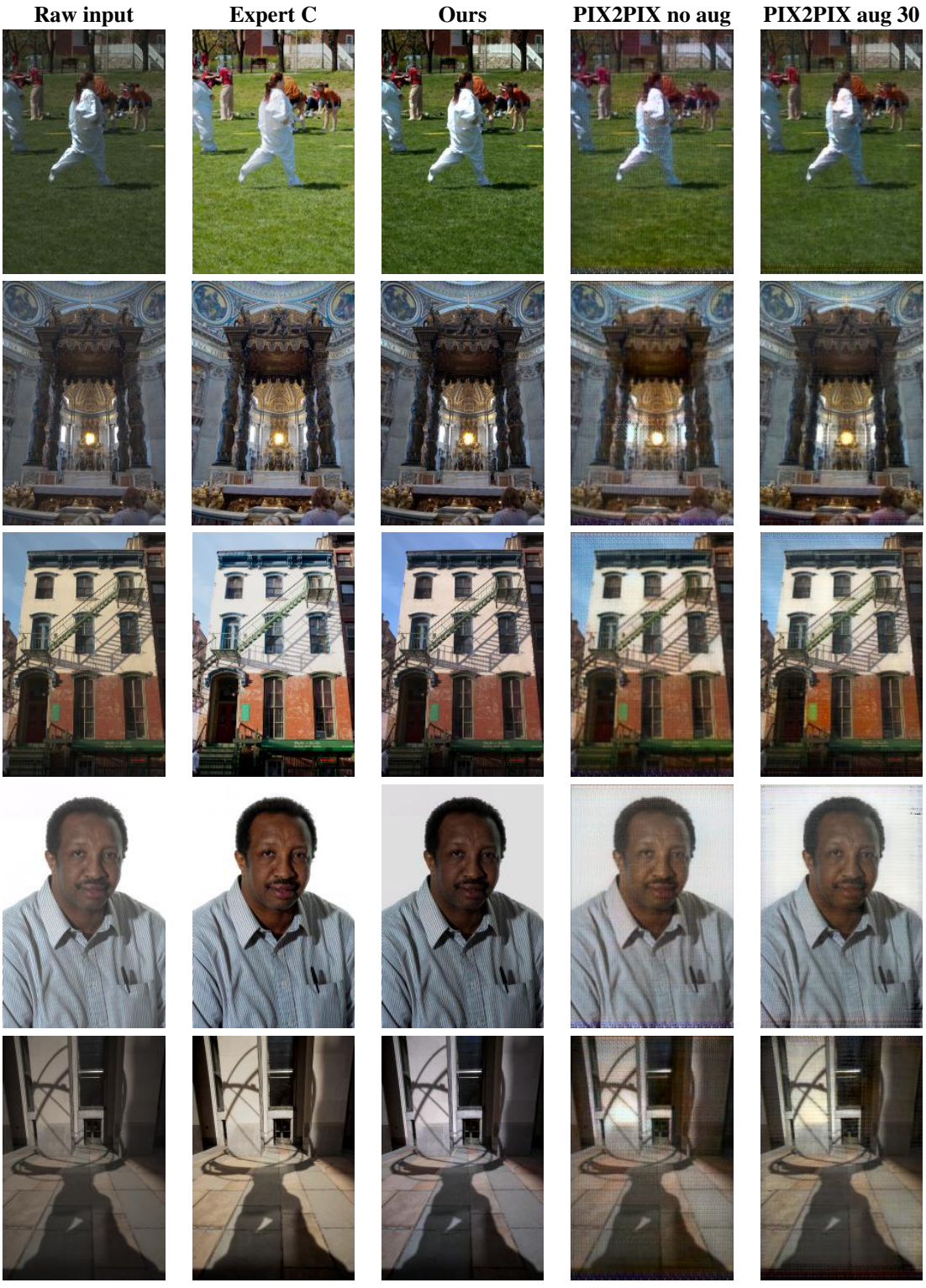


Table 219. [18 / 37] Experiment results using distort-and-recover scheme

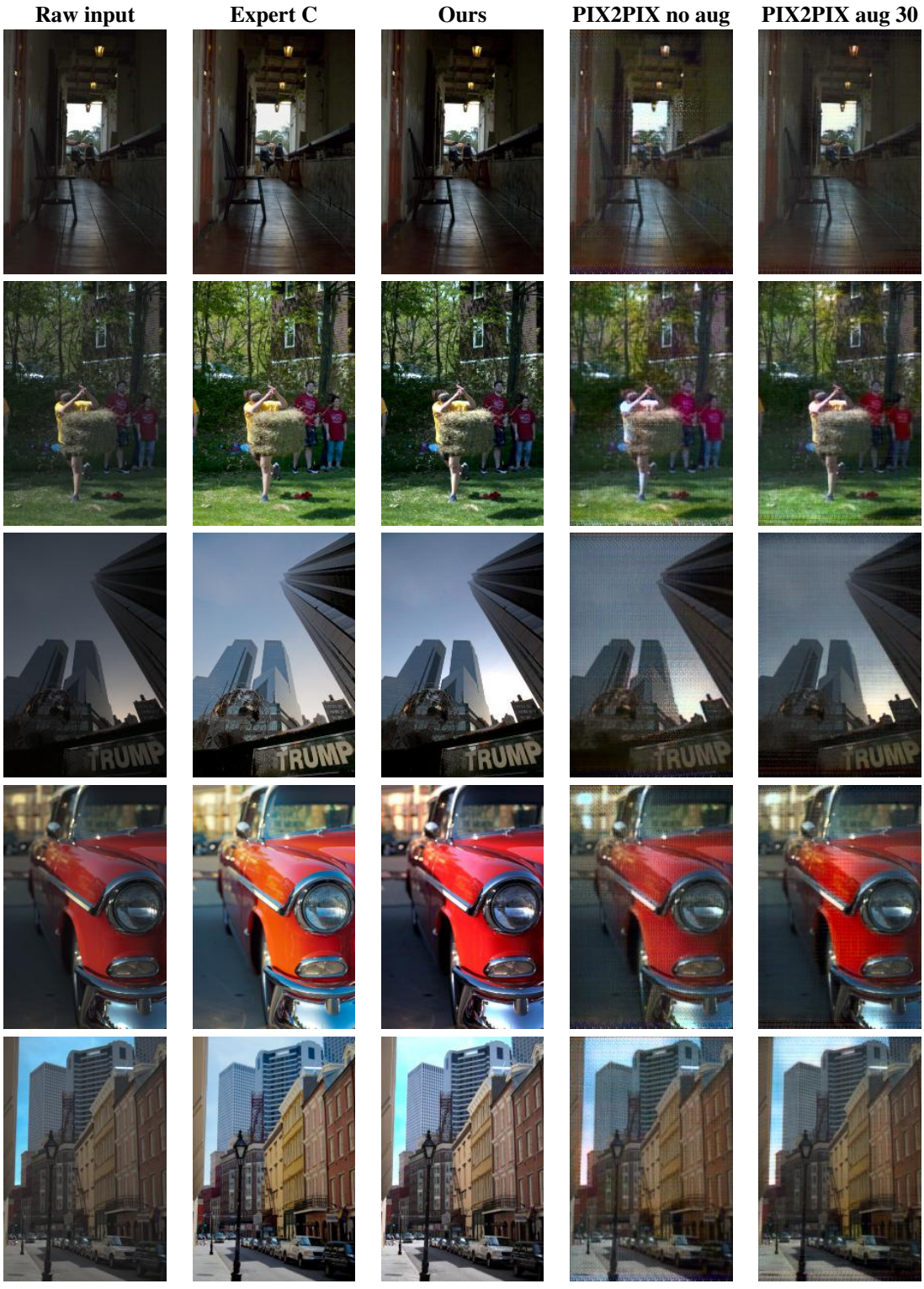


Table 220. [19 / 37] Experiment results using distort-and-recover scheme

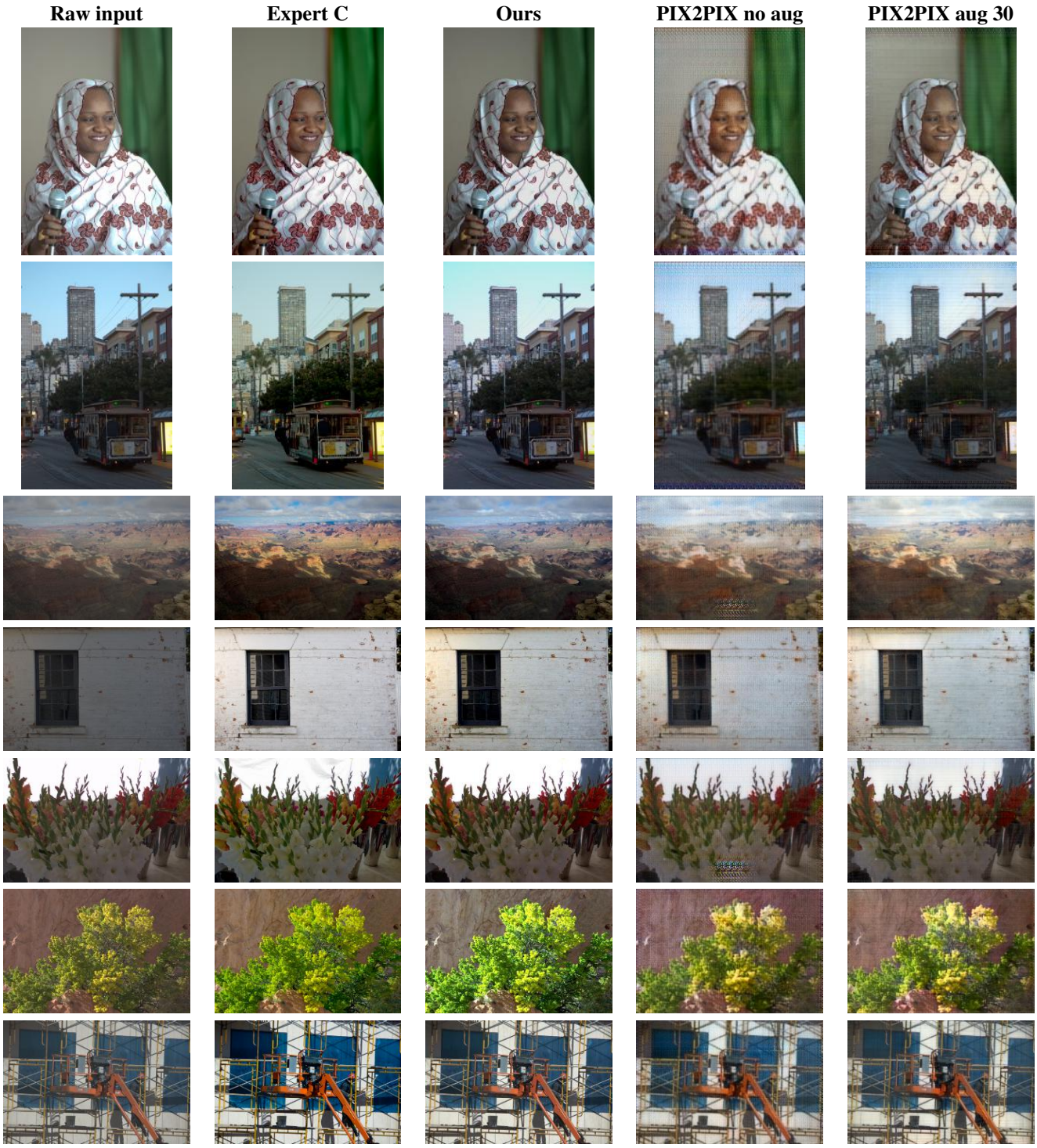


Table 221. [20 / 37] Experiment results using distort-and-recover scheme

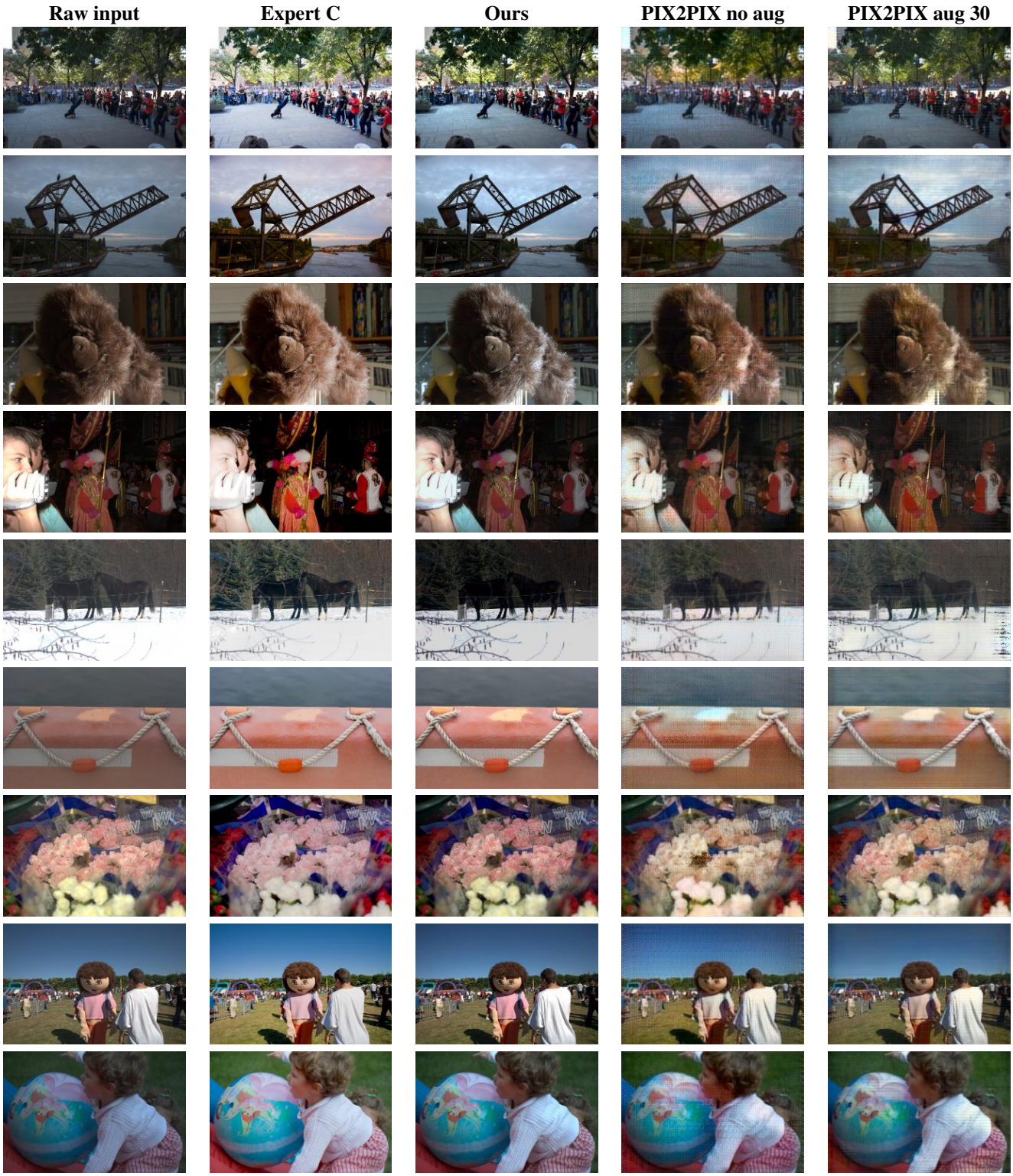


Table 222. [21 / 37] Experiment results using distort-and-recover scheme

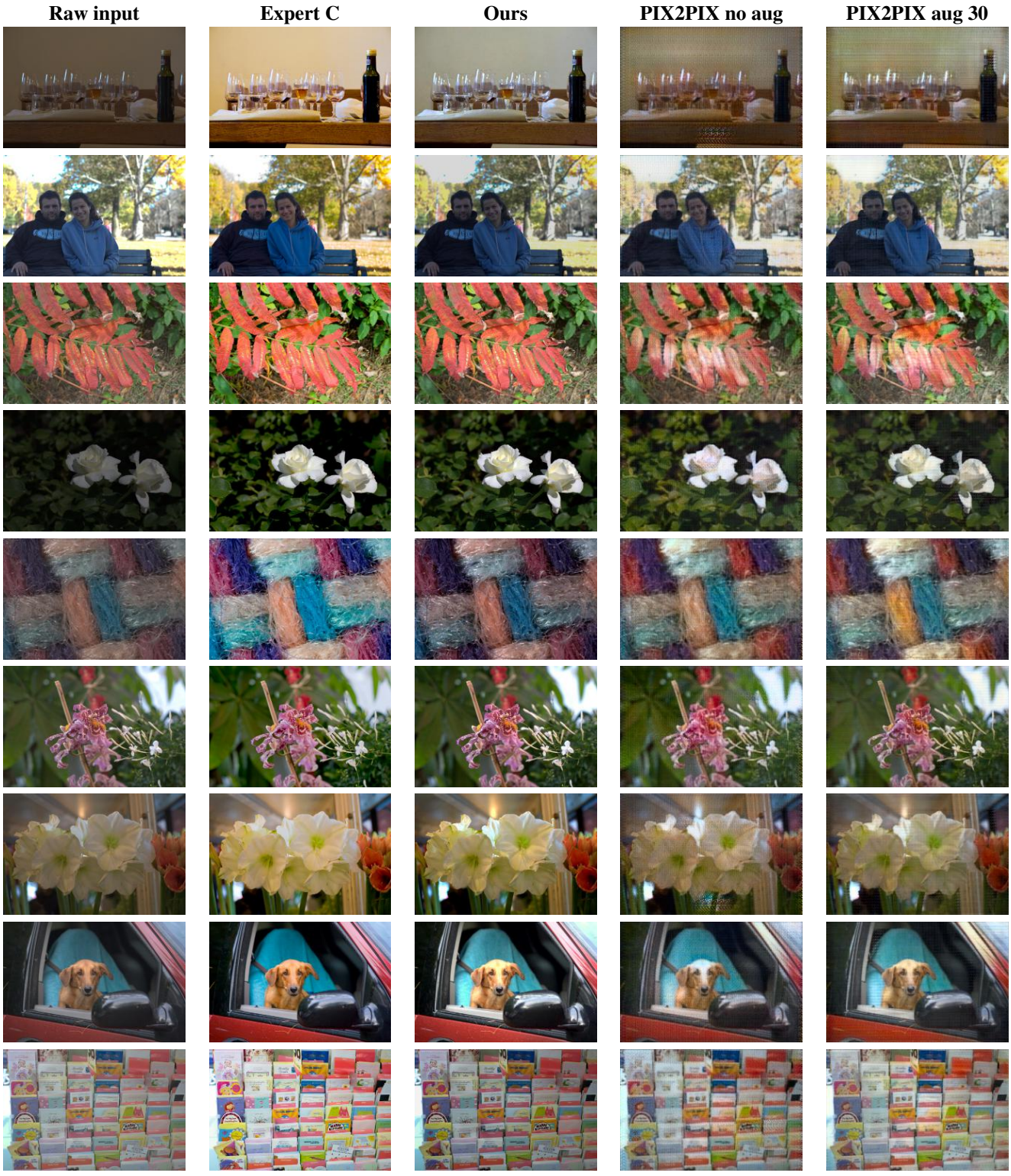


Table 223. [22 / 37] Experiment results using distort-and-recover scheme

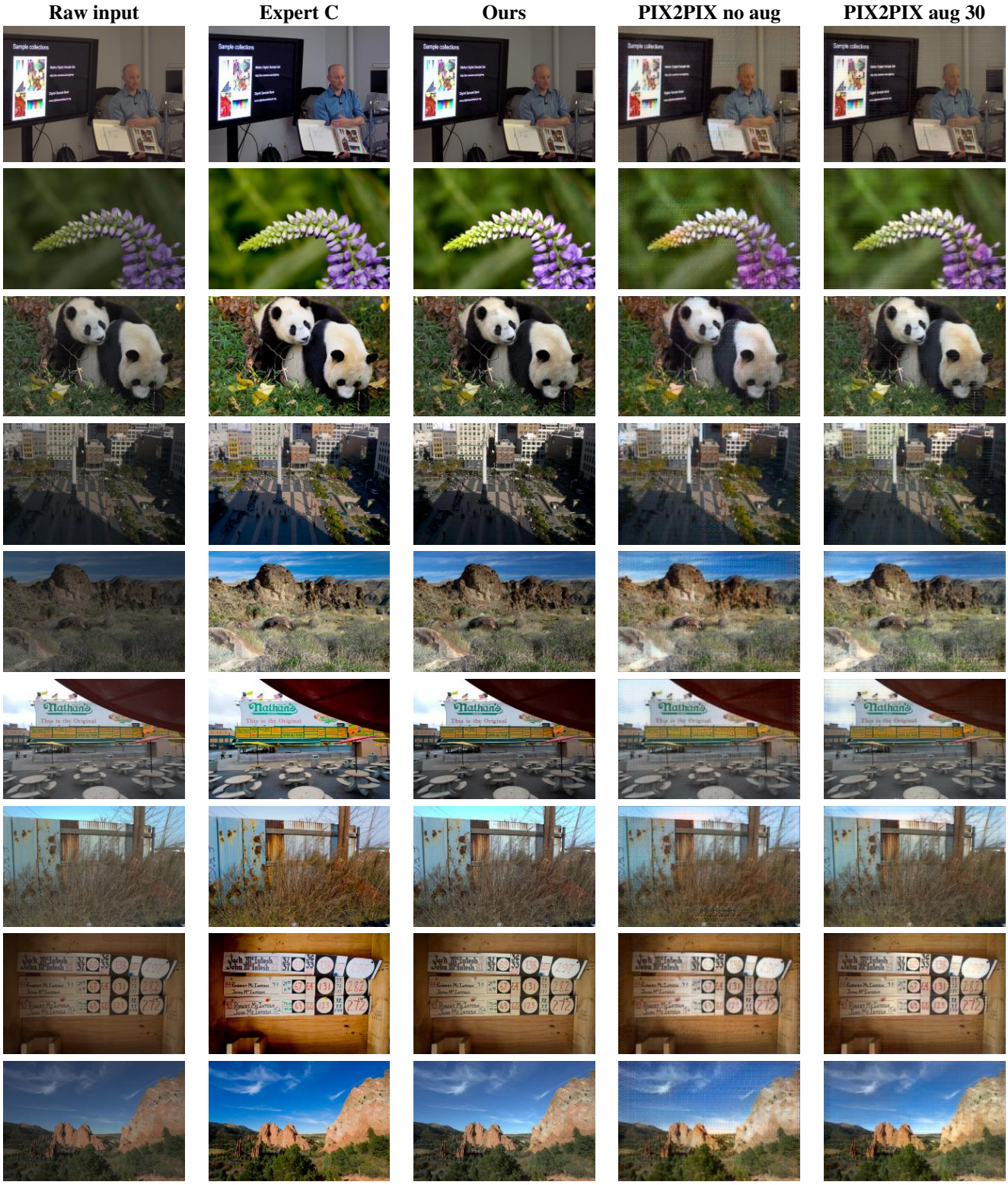


Table 224. [23 / 37] Experiment results using distort-and-recover scheme

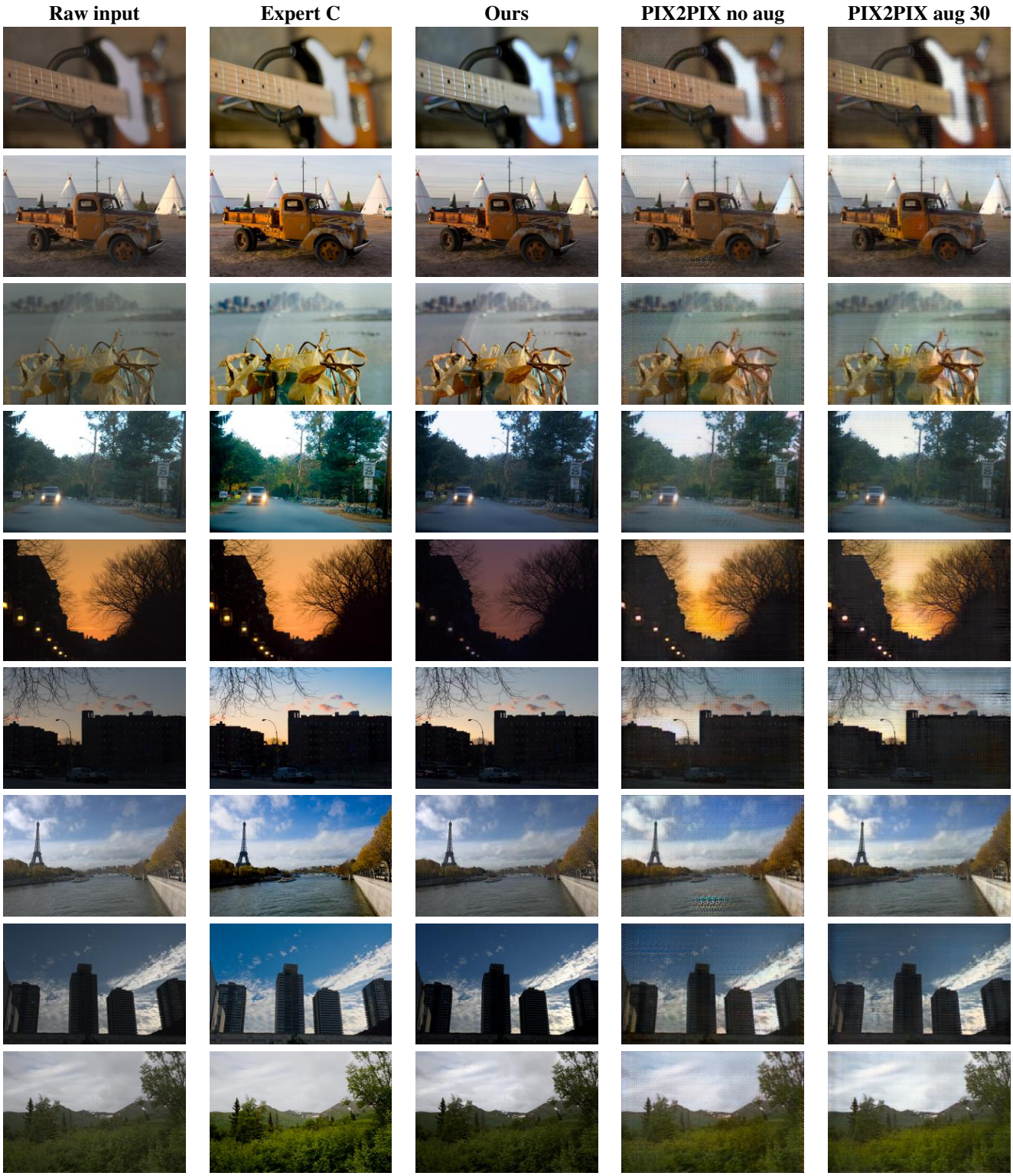


Table 225. [24 / 37] Experiment results using distort-and-recover scheme

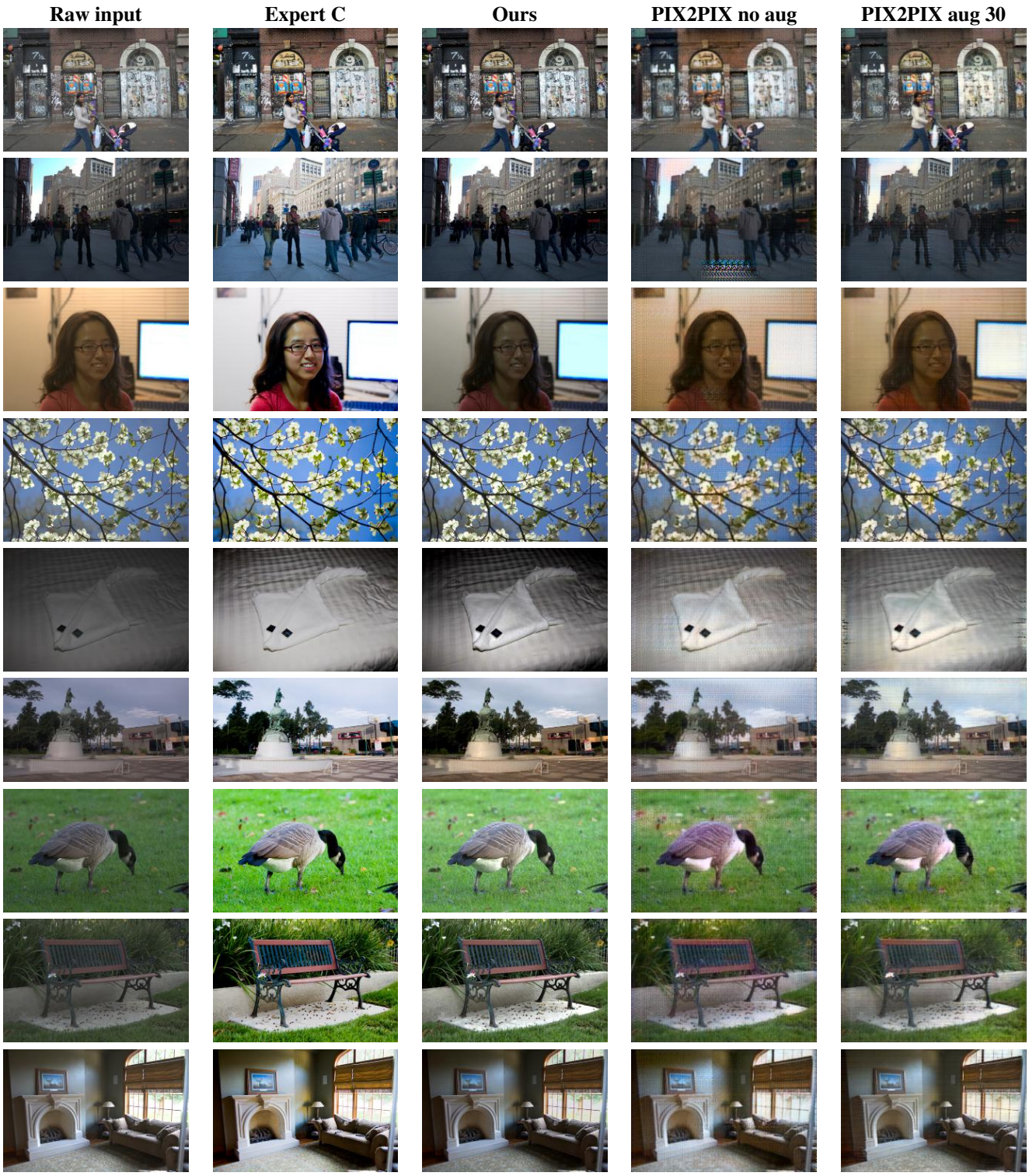


Table 226. [25 / 37] Experiment results using distort-and-recover scheme

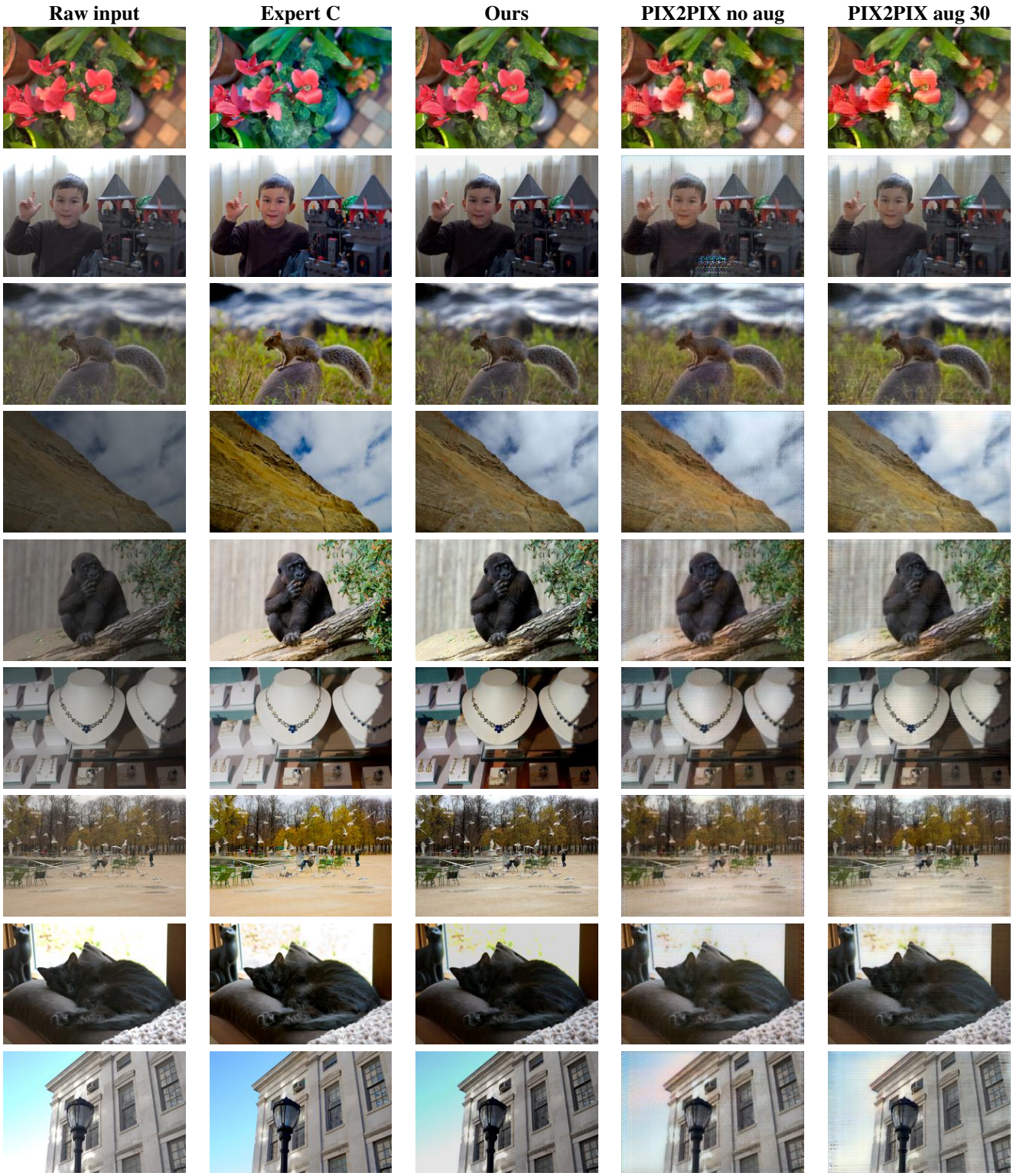


Table 227. [26 / 37] Experiment results using distort-and-recover scheme

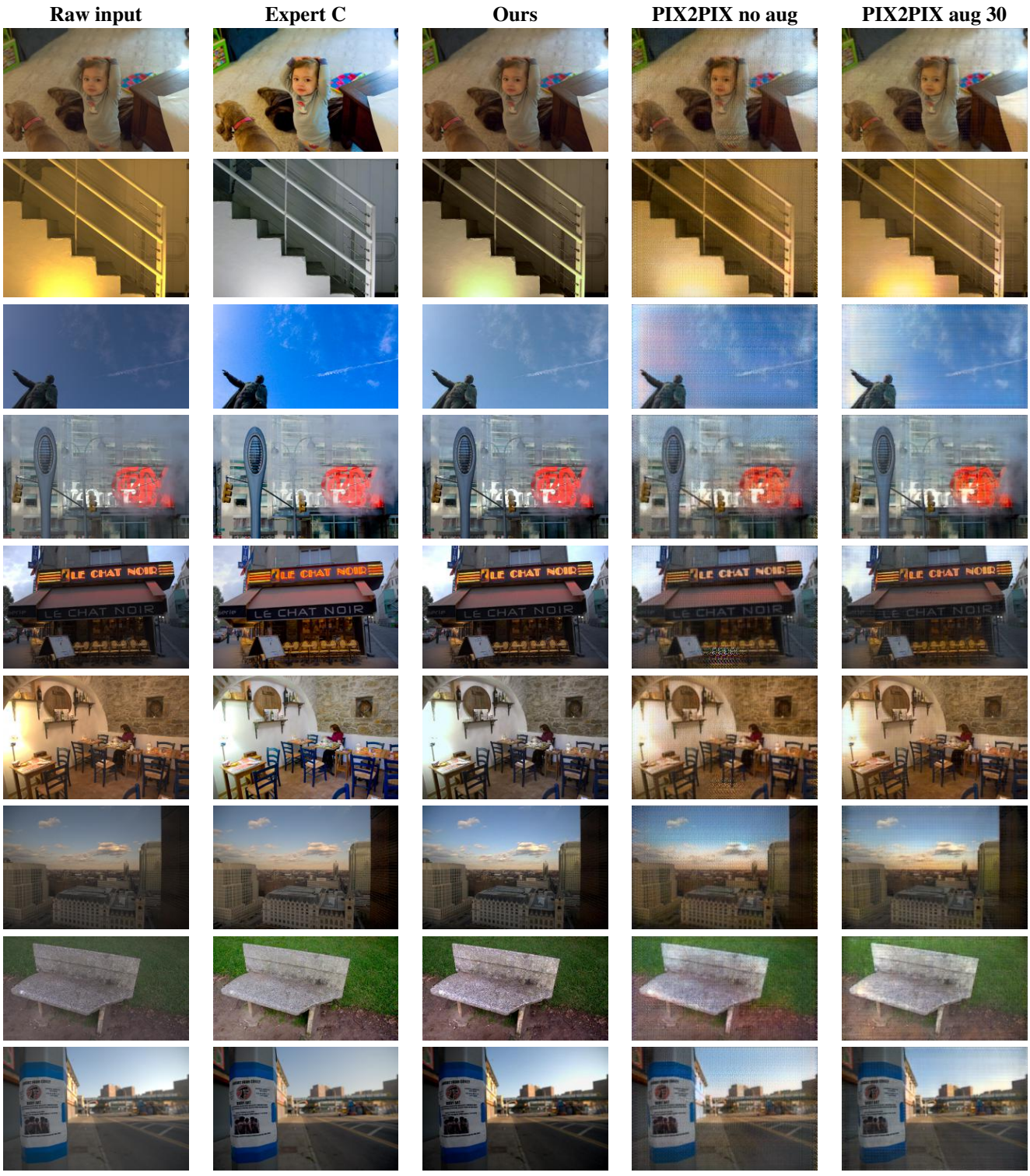


Table 228. [27 / 37] Experiment results using distort-and-recover scheme

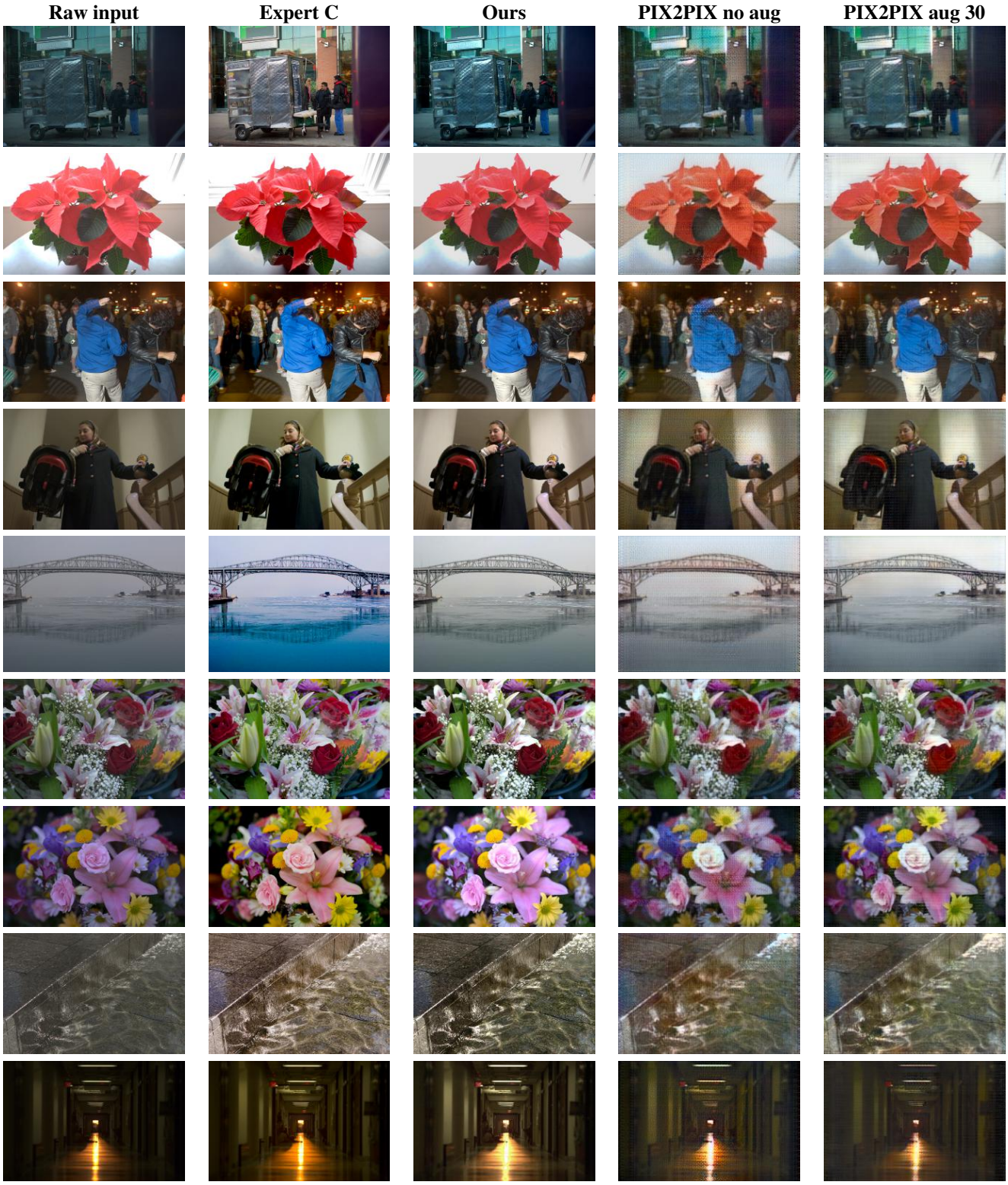


Table 229. [28 / 37] Experiment results using distort-and-recover scheme

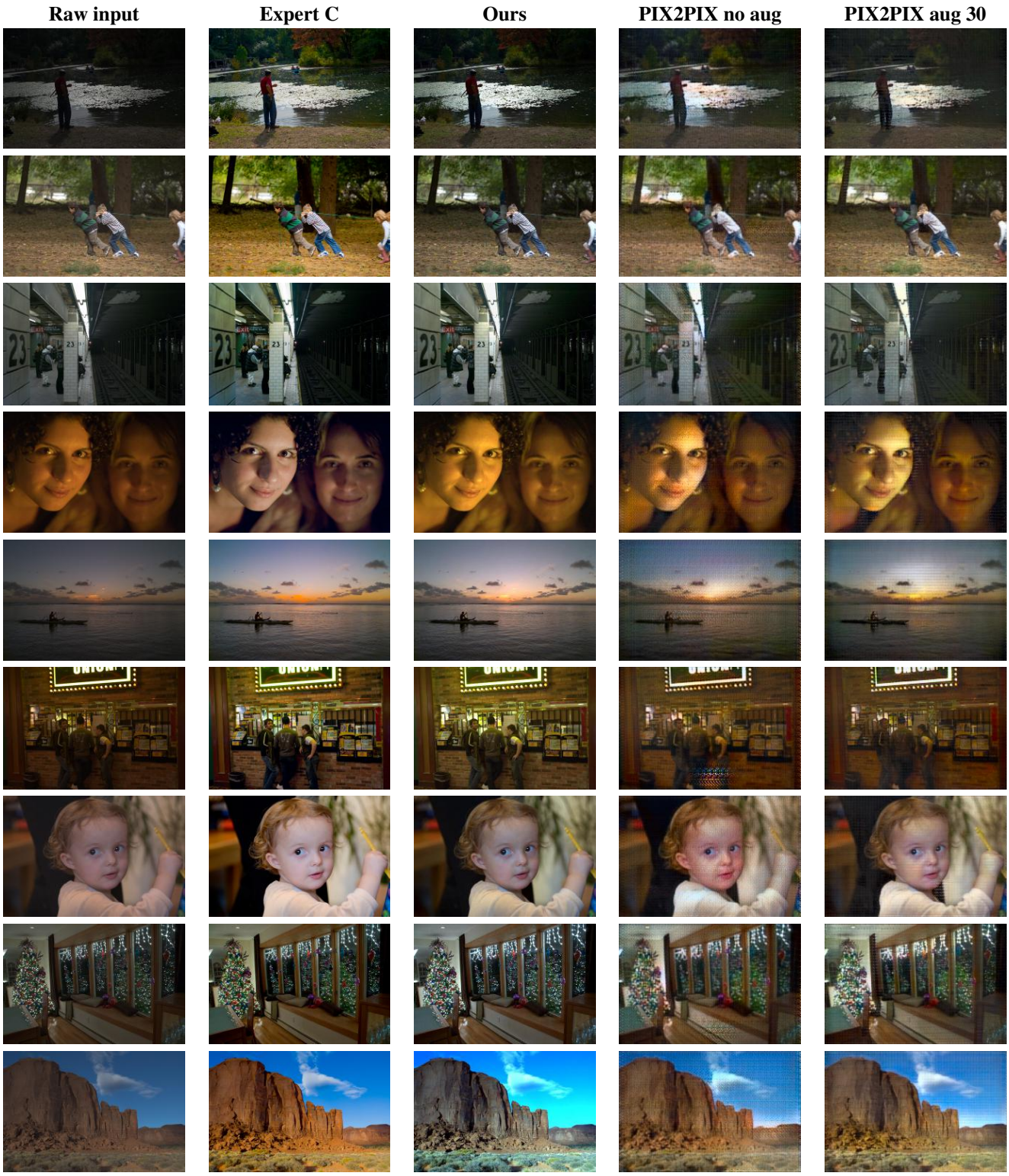


Table 230. [29 / 37] Experiment results using distort-and-recover scheme

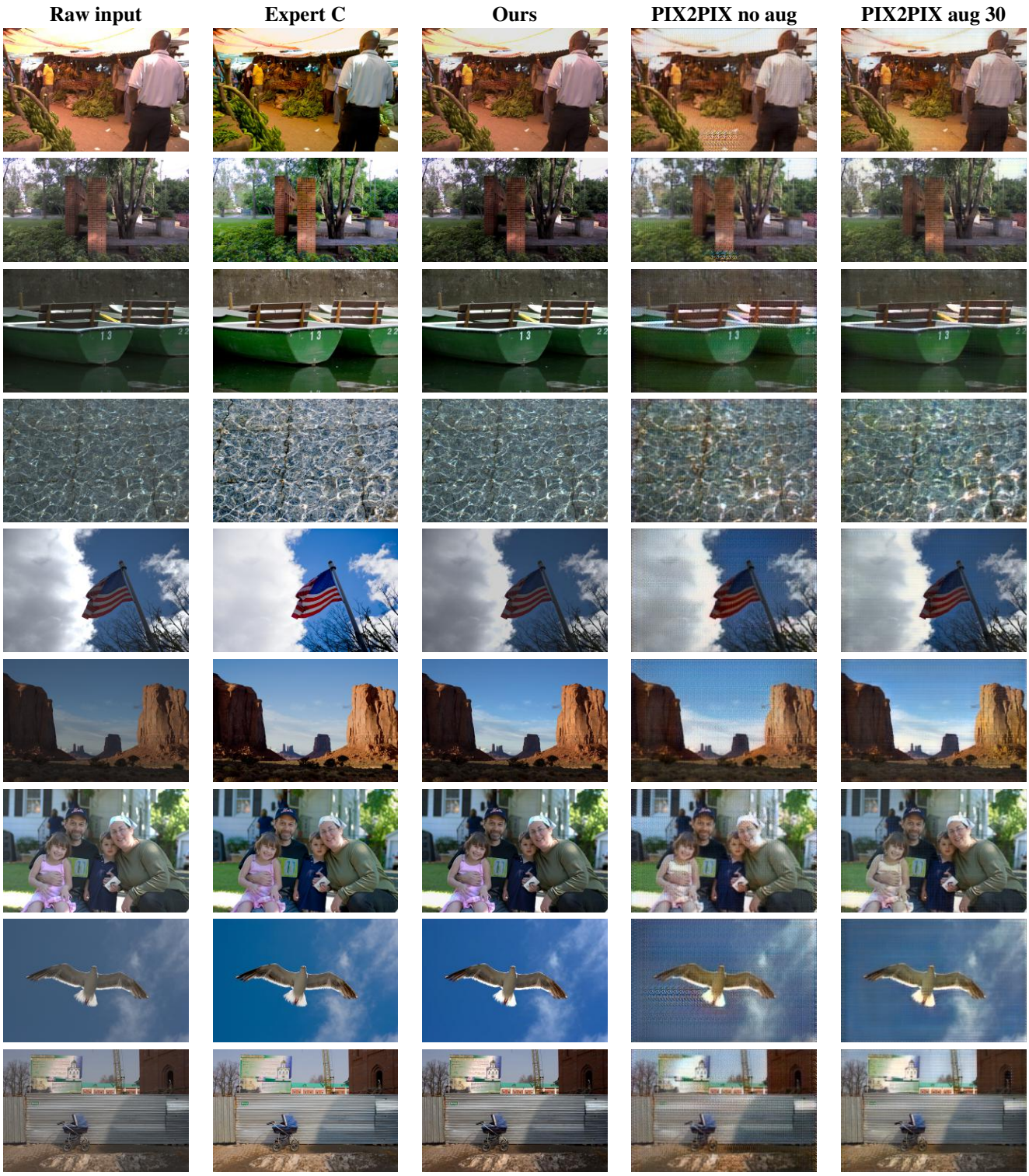


Table 231. [30 / 37] Experiment results using distort-and-recover scheme

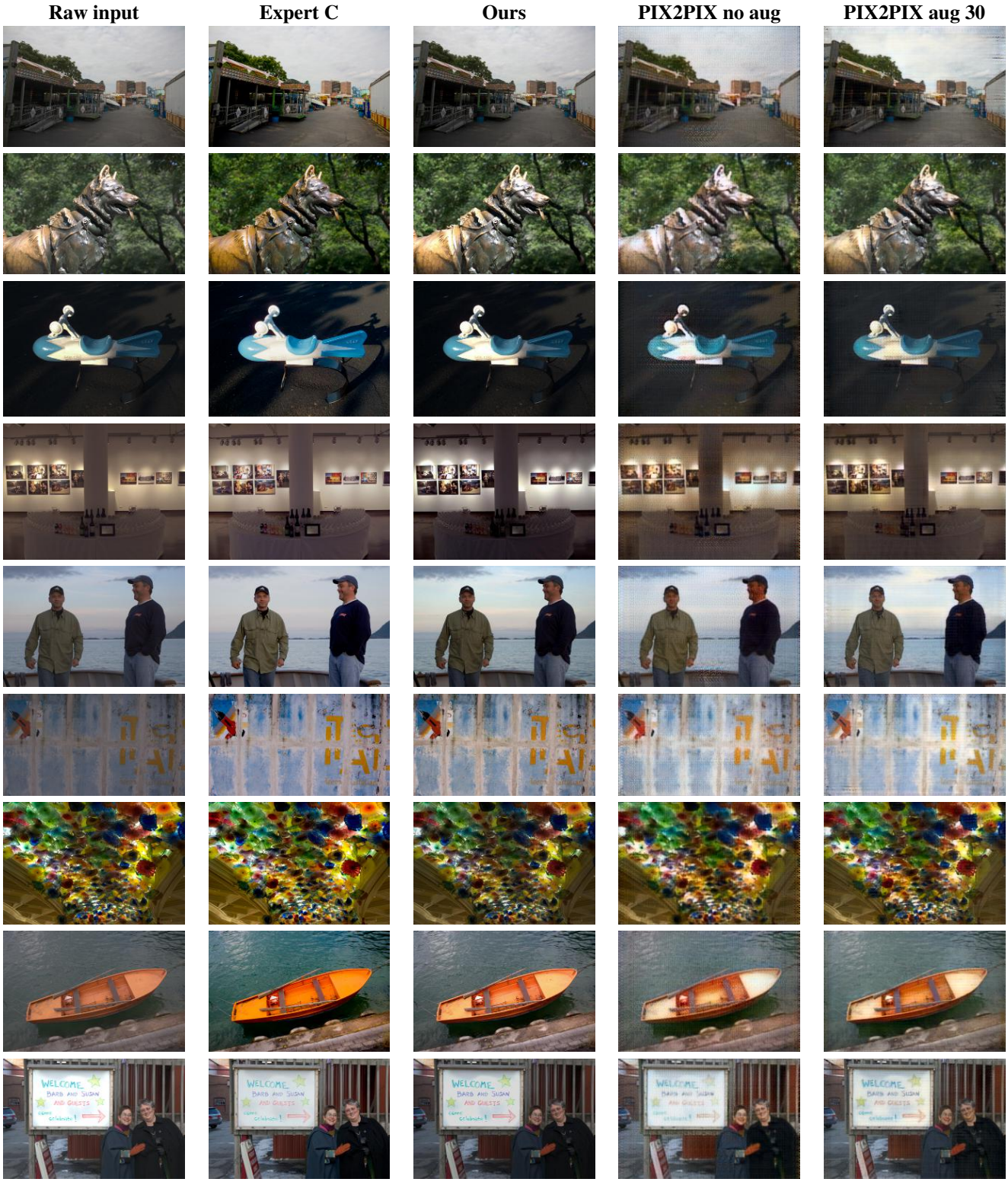


Table 232. [31 / 37] Experiment results using distort-and-recover scheme

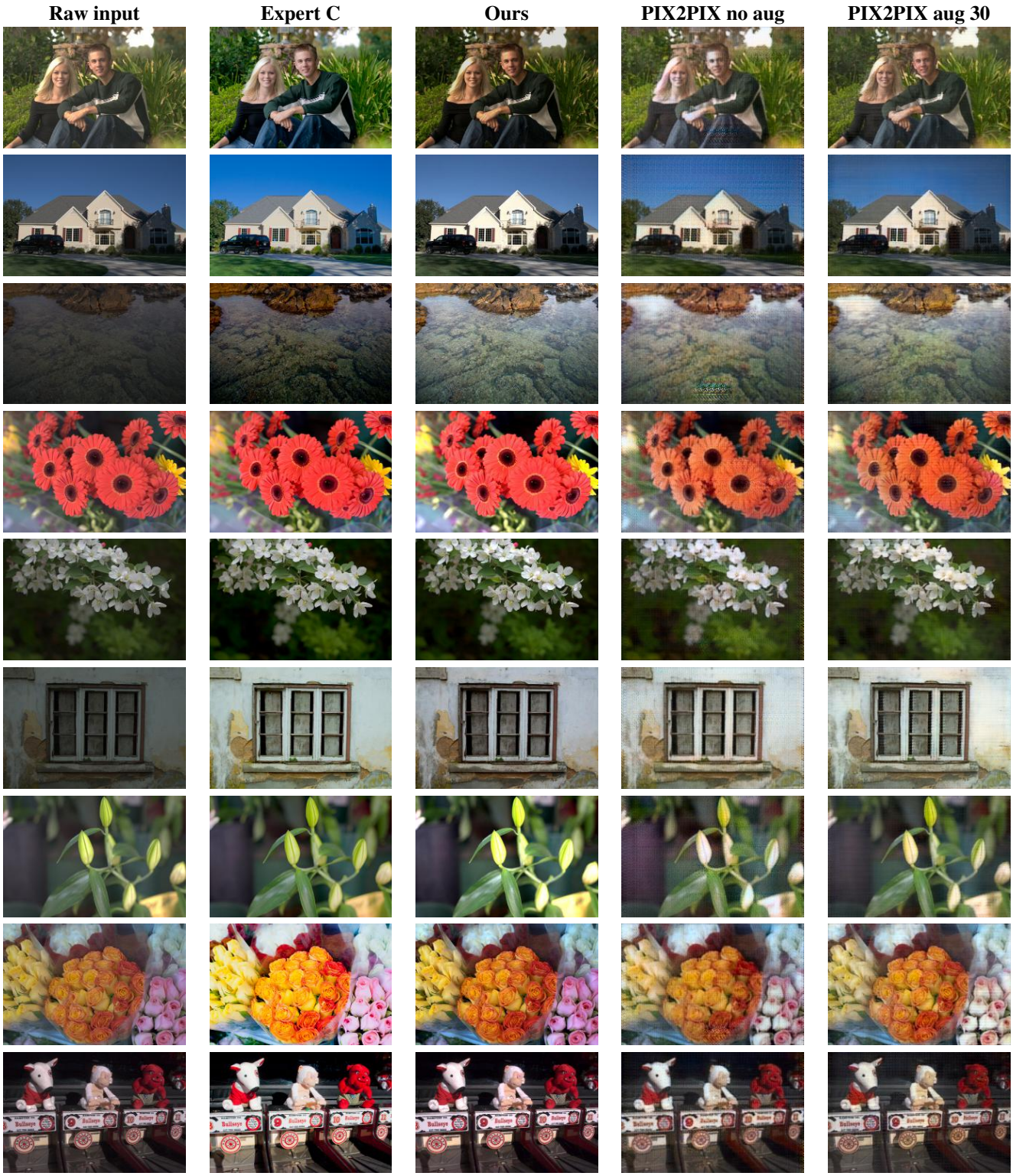


Table 233. [32 / 37] Experiment results using distort-and-recover scheme

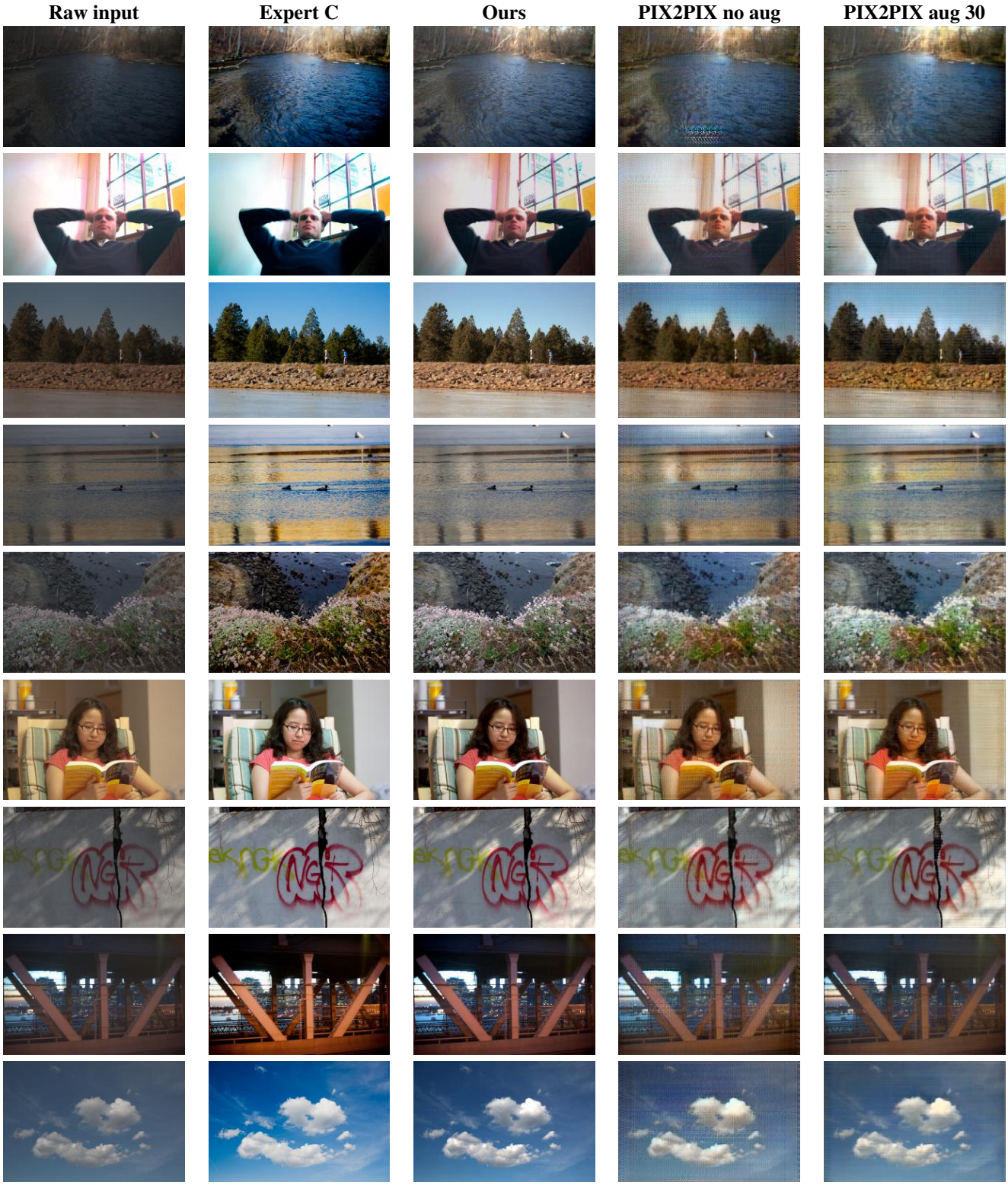


Table 234. [33 / 37] Experiment results using distort-and-recover scheme

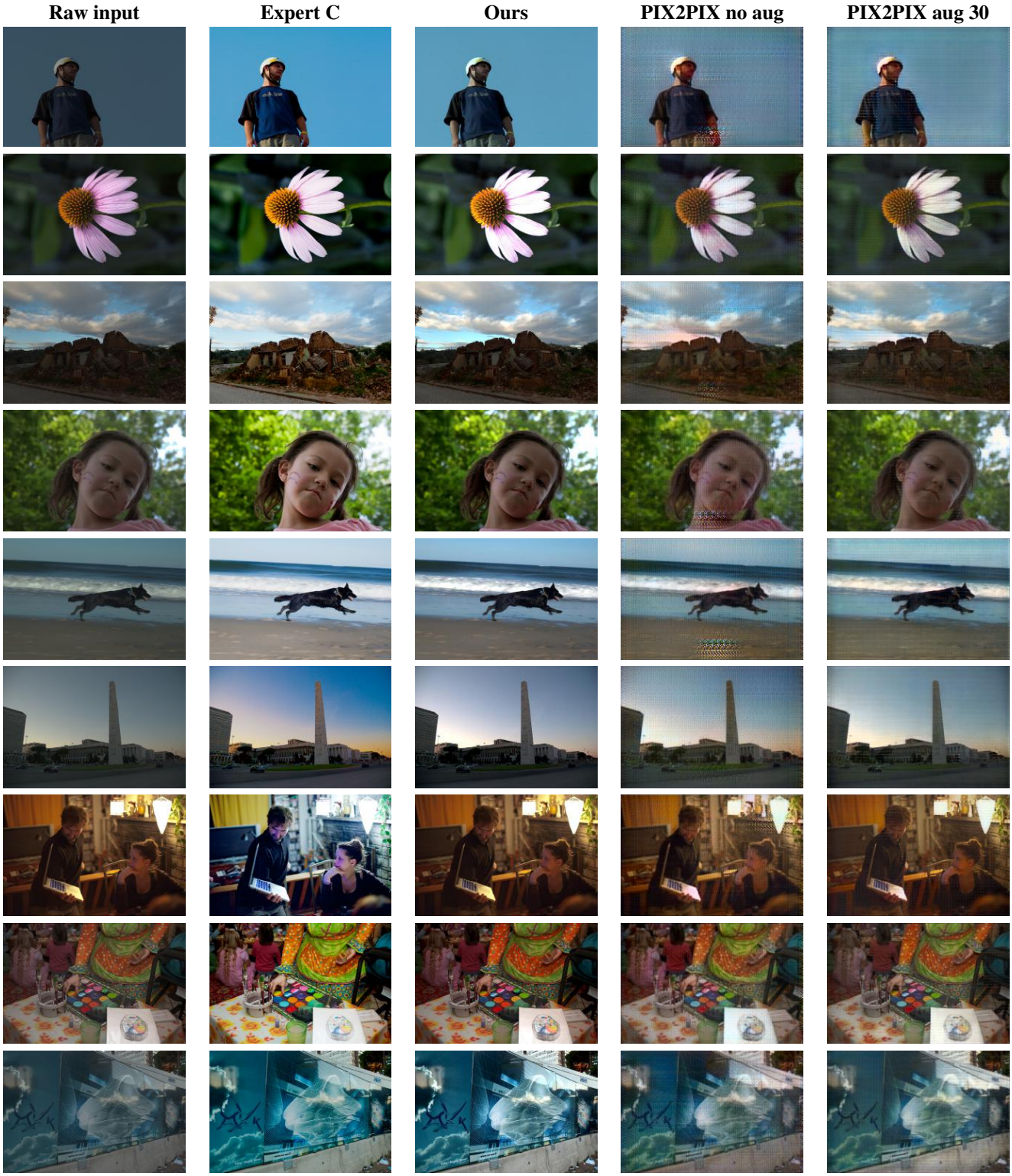


Table 235. [34 / 37] Experiment results using distort-and-recover scheme

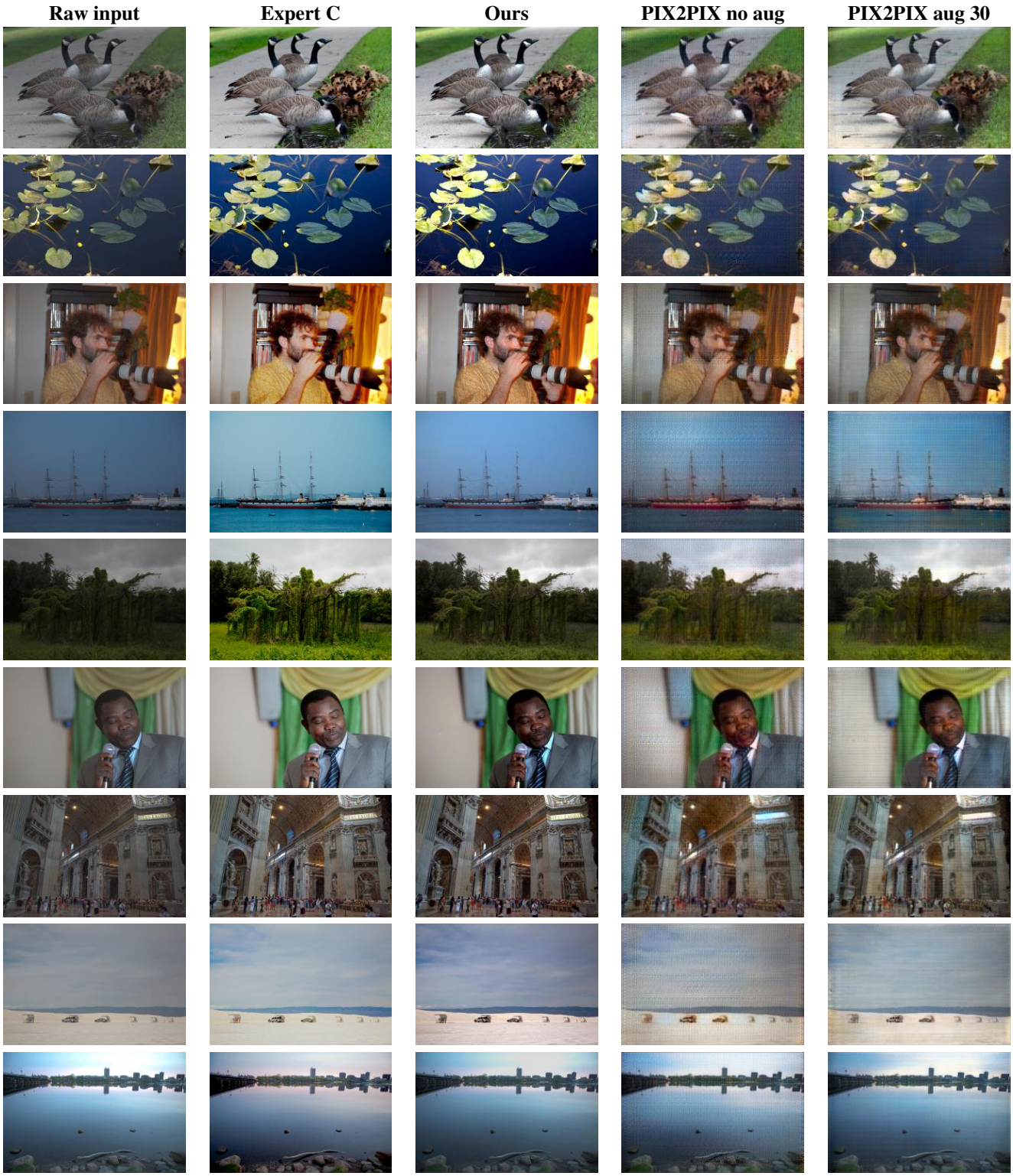


Table 236. [35 / 37] Experiment results using distort-and-recover scheme

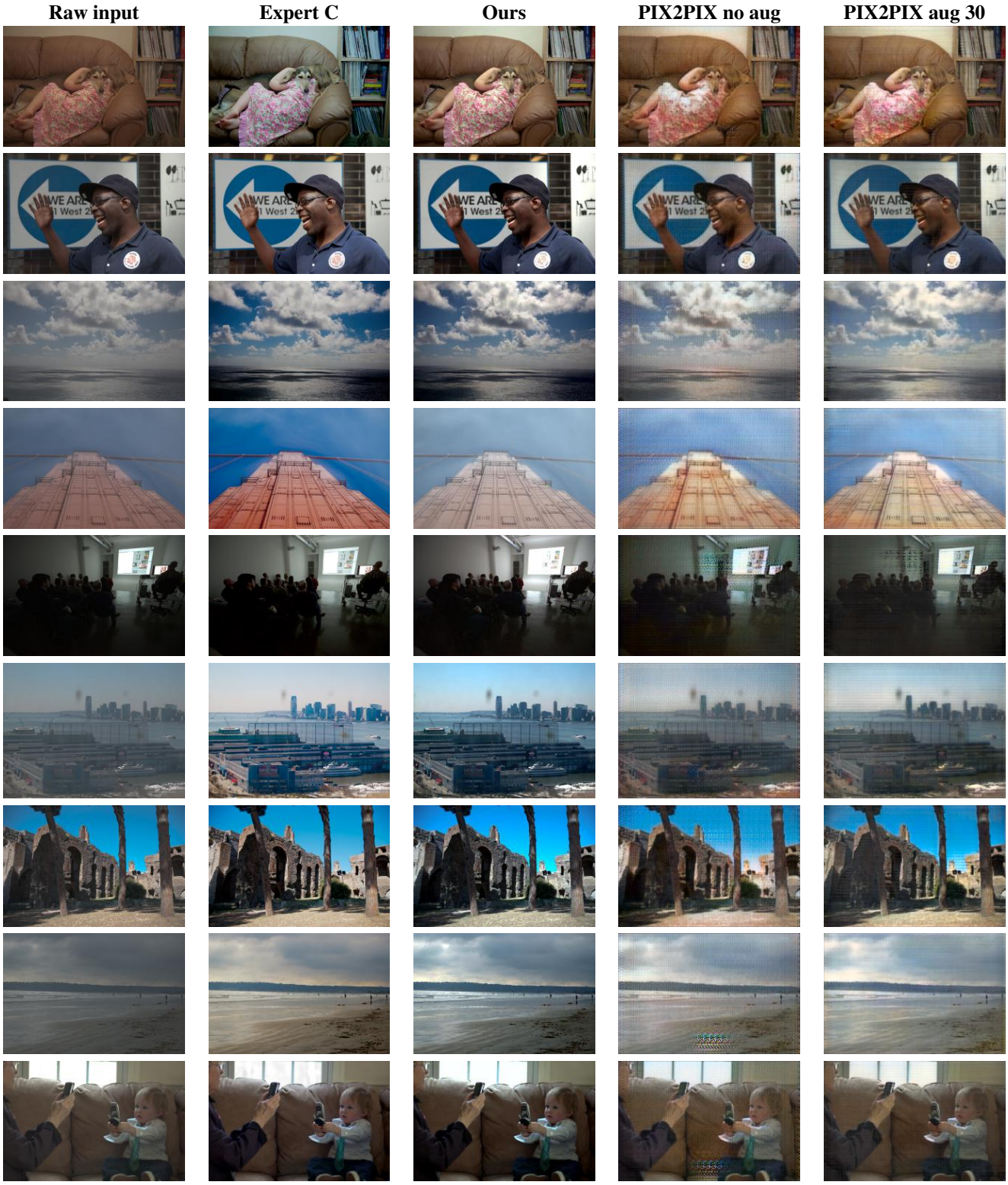


Table 237. [36 / 37] Experiment results using distort-and-recover scheme

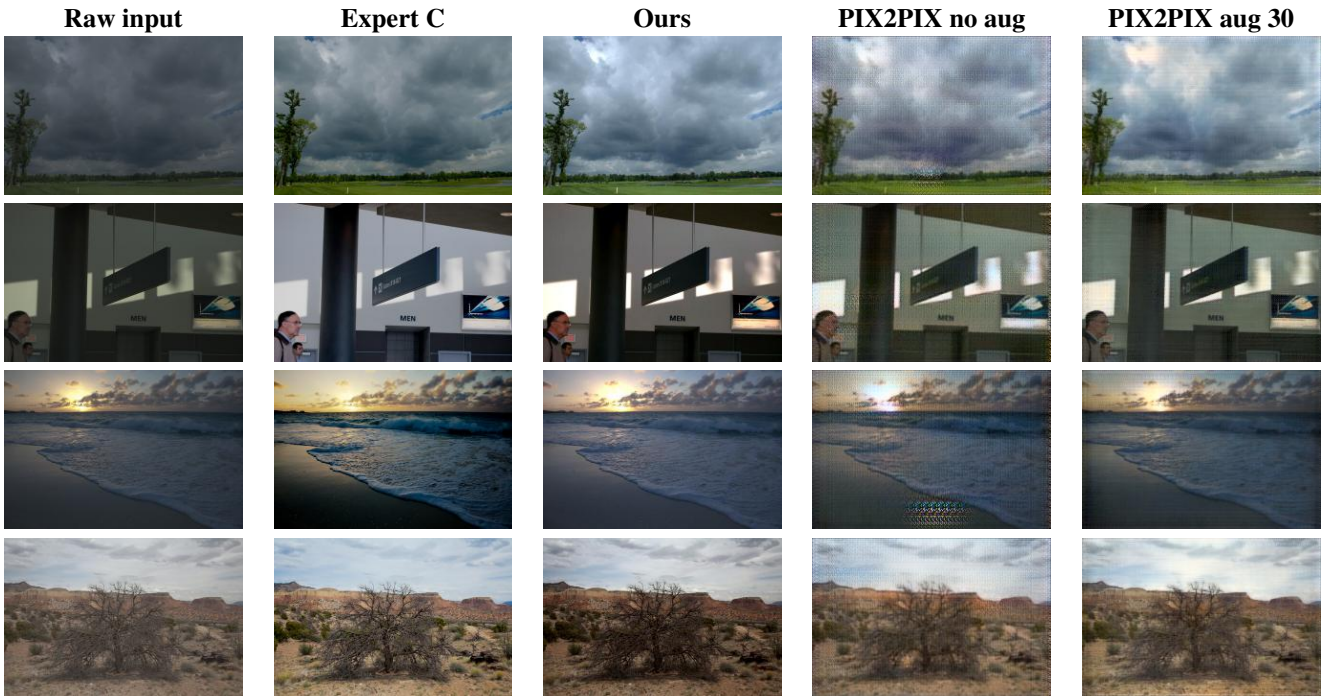


Table 238. [37 / 37] Experiment results using distort-and-recover scheme

4.6. Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

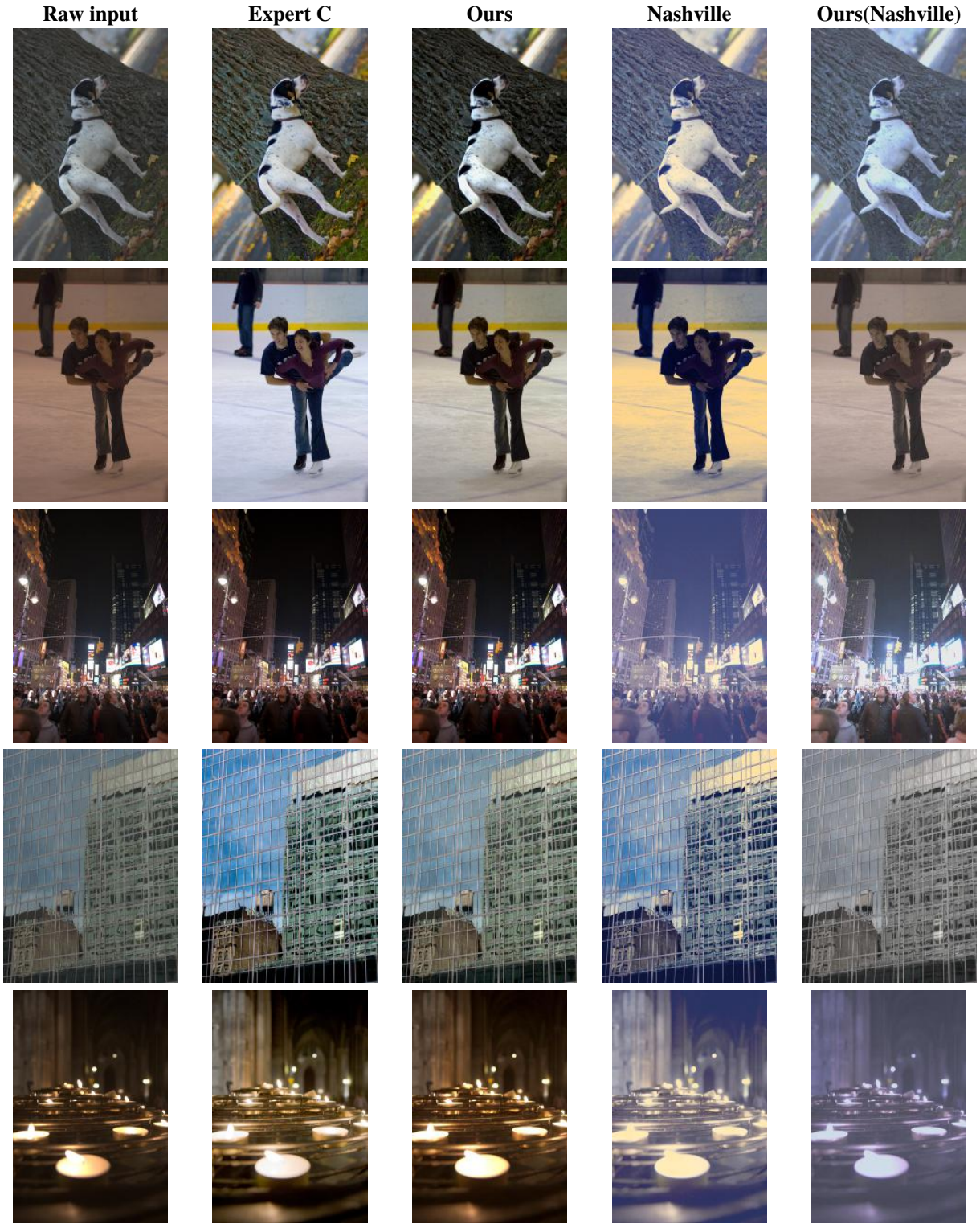


Table 239. [1 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

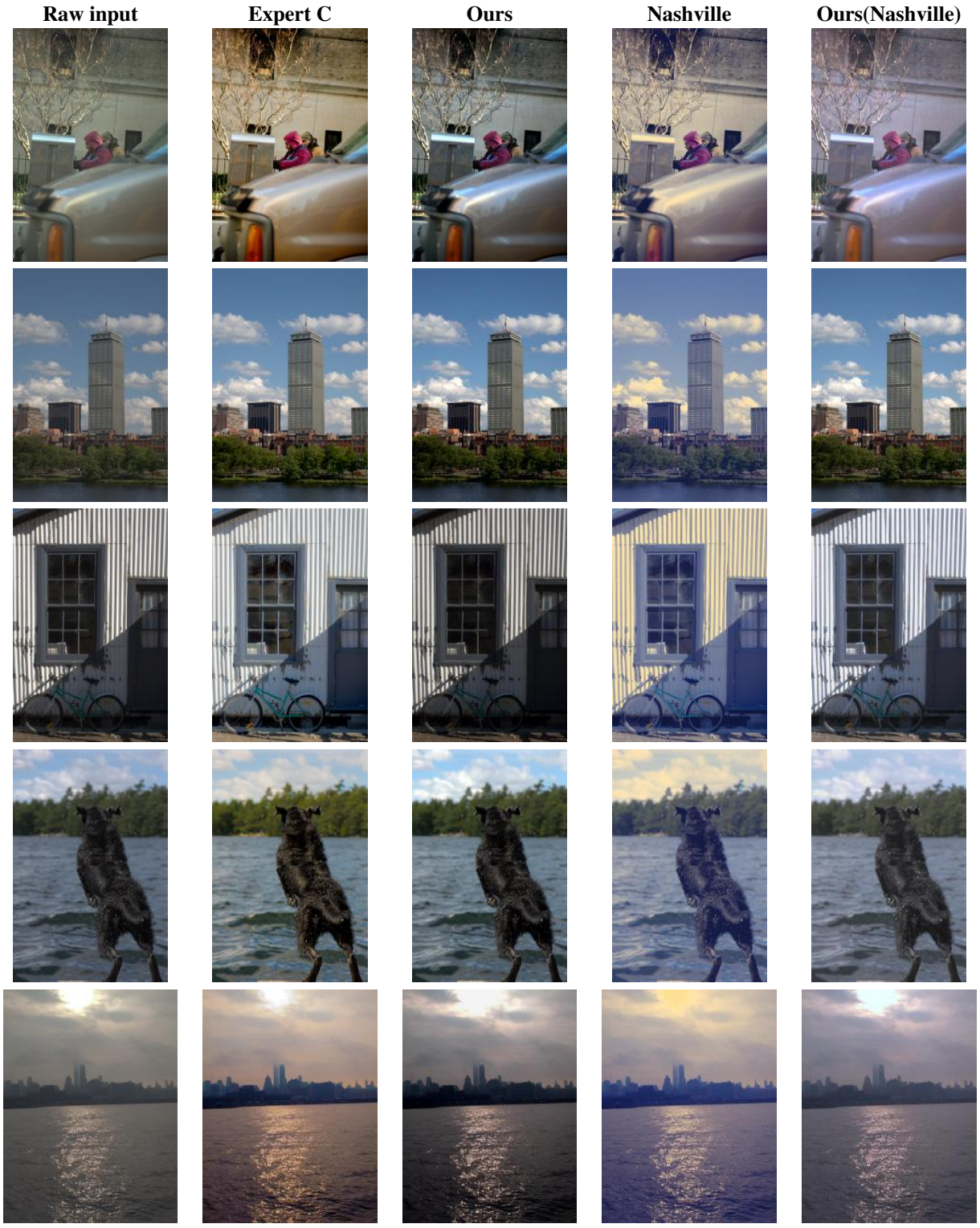


Table 240. [2 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

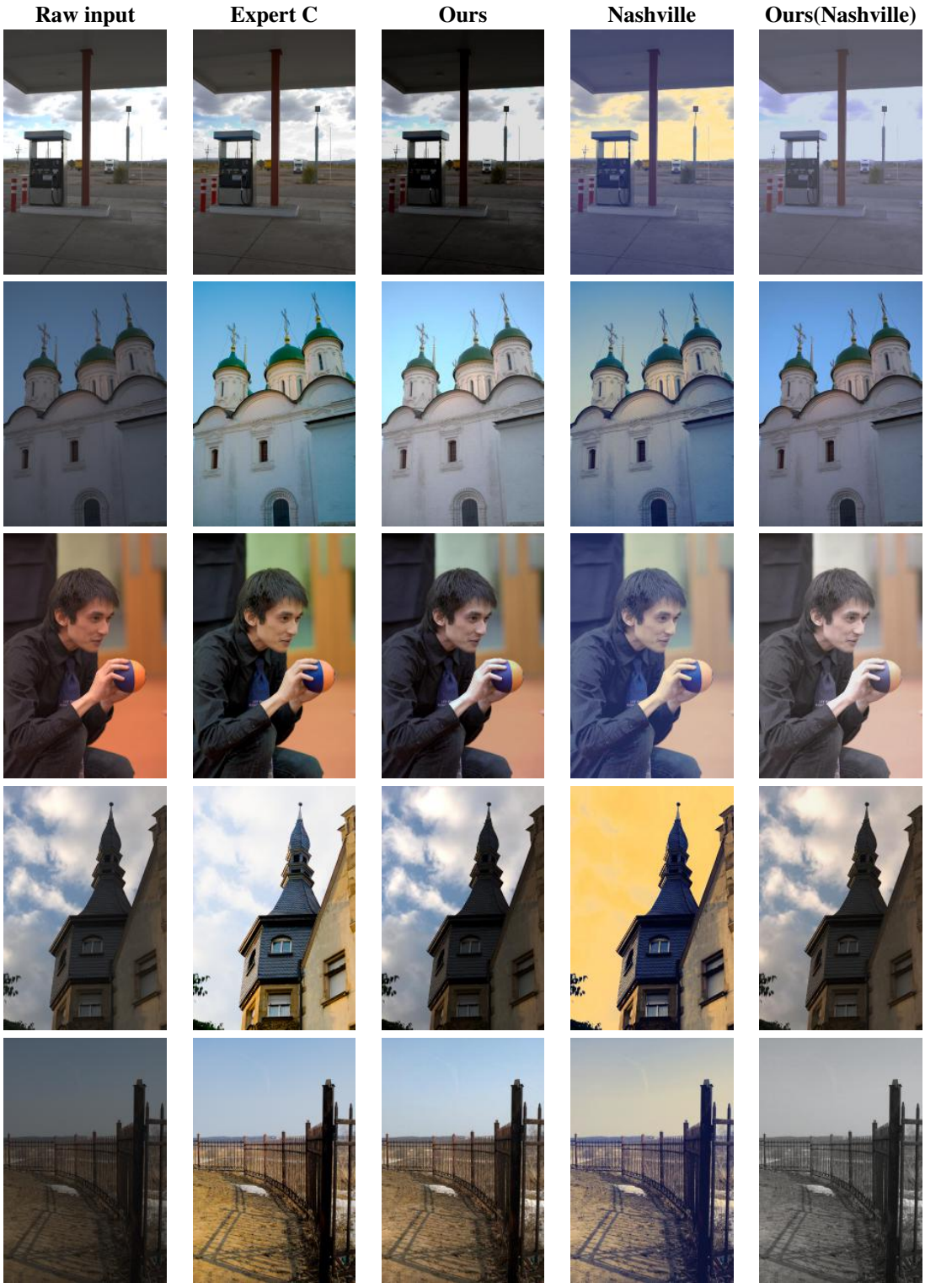


Table 241. [3 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

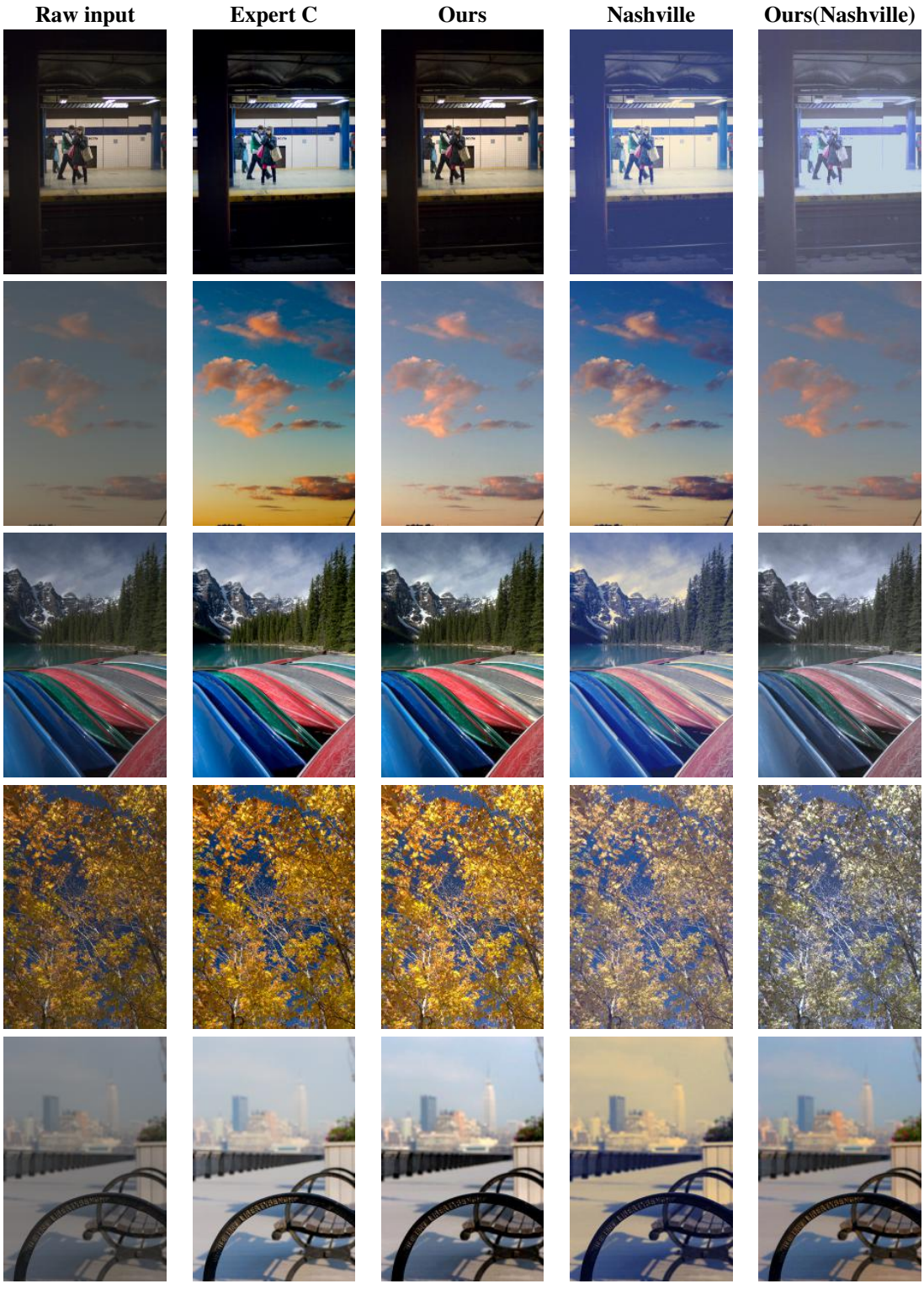


Table 242. [4 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

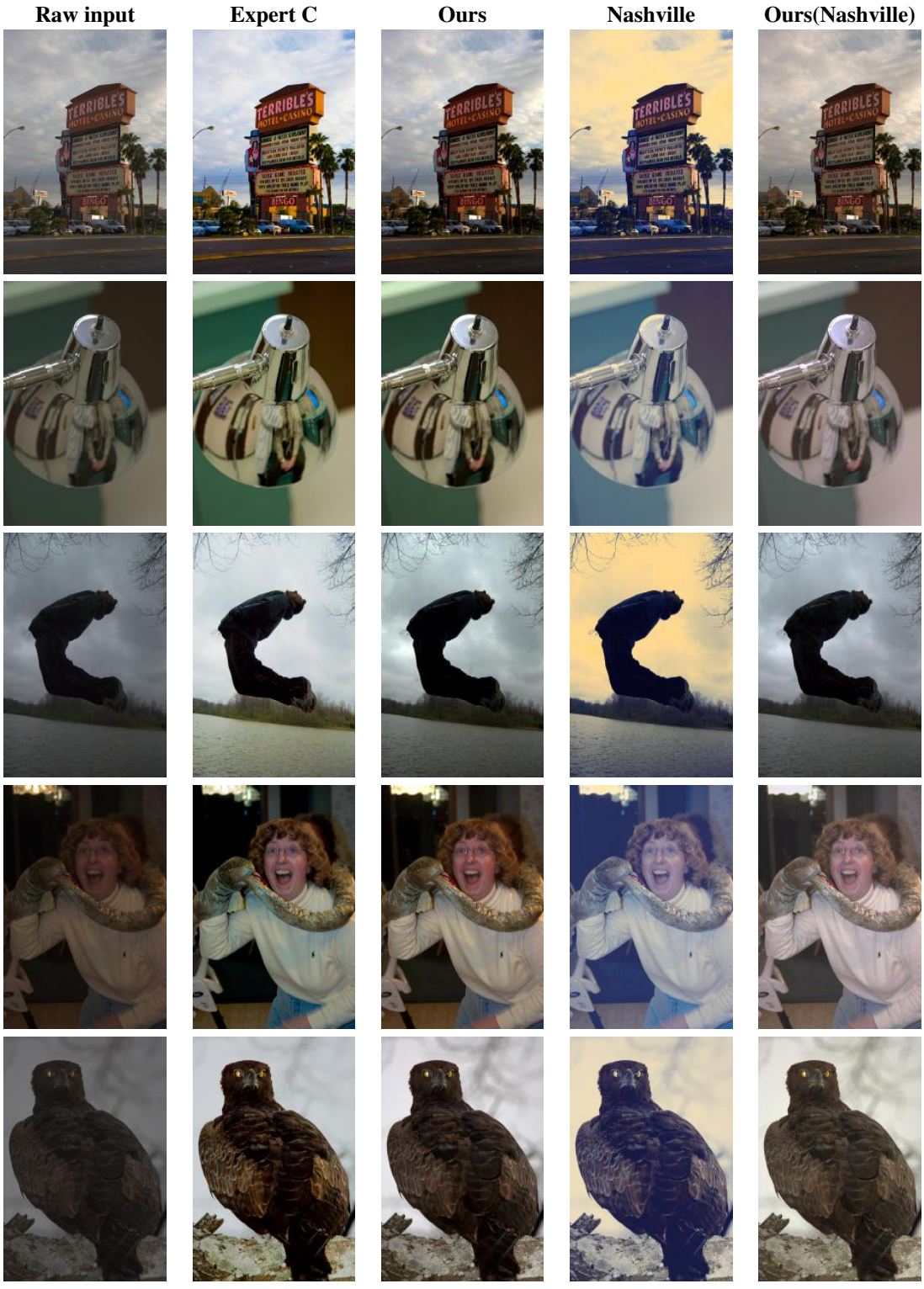


Table 243. [5 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

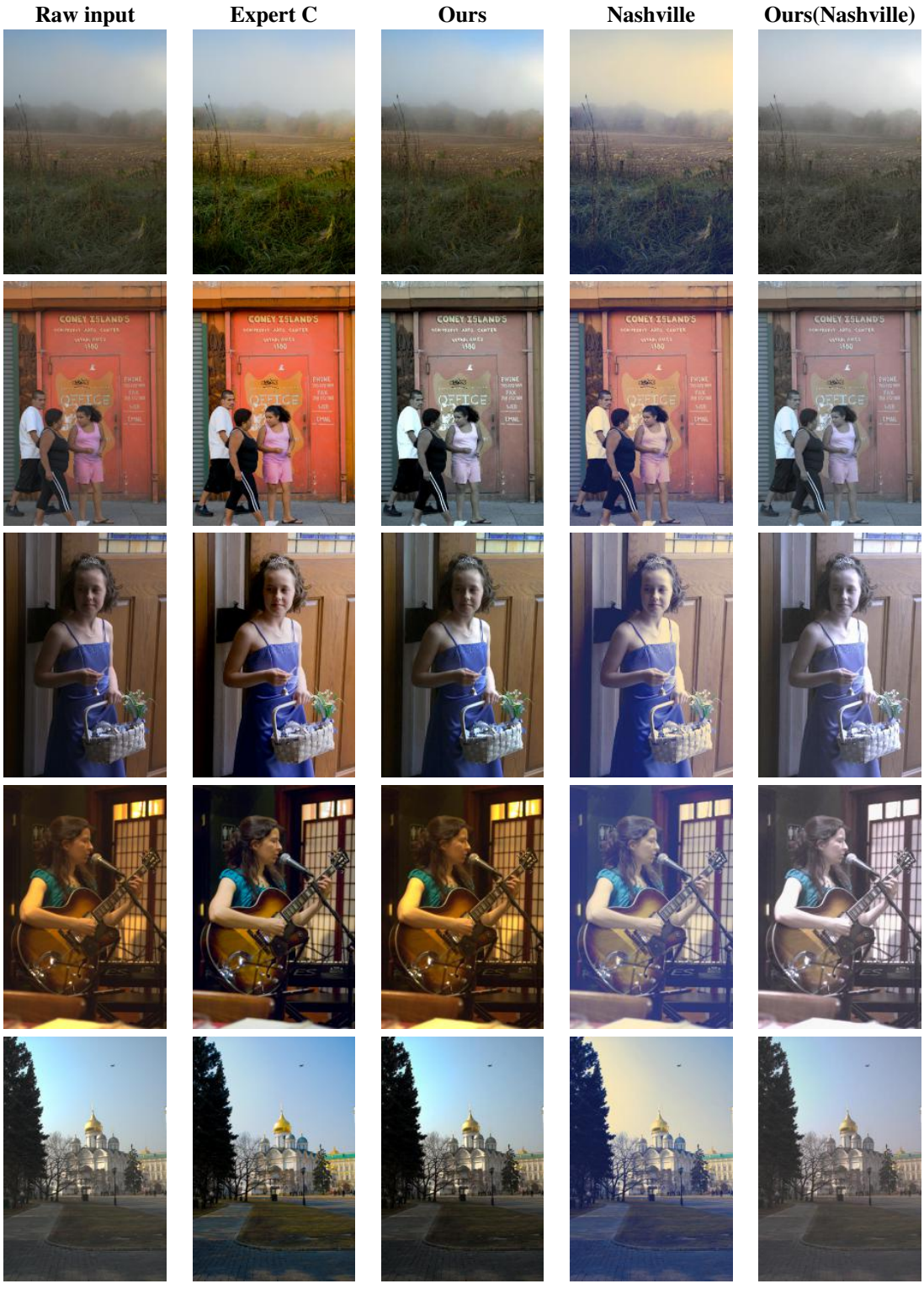


Table 244. [6 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

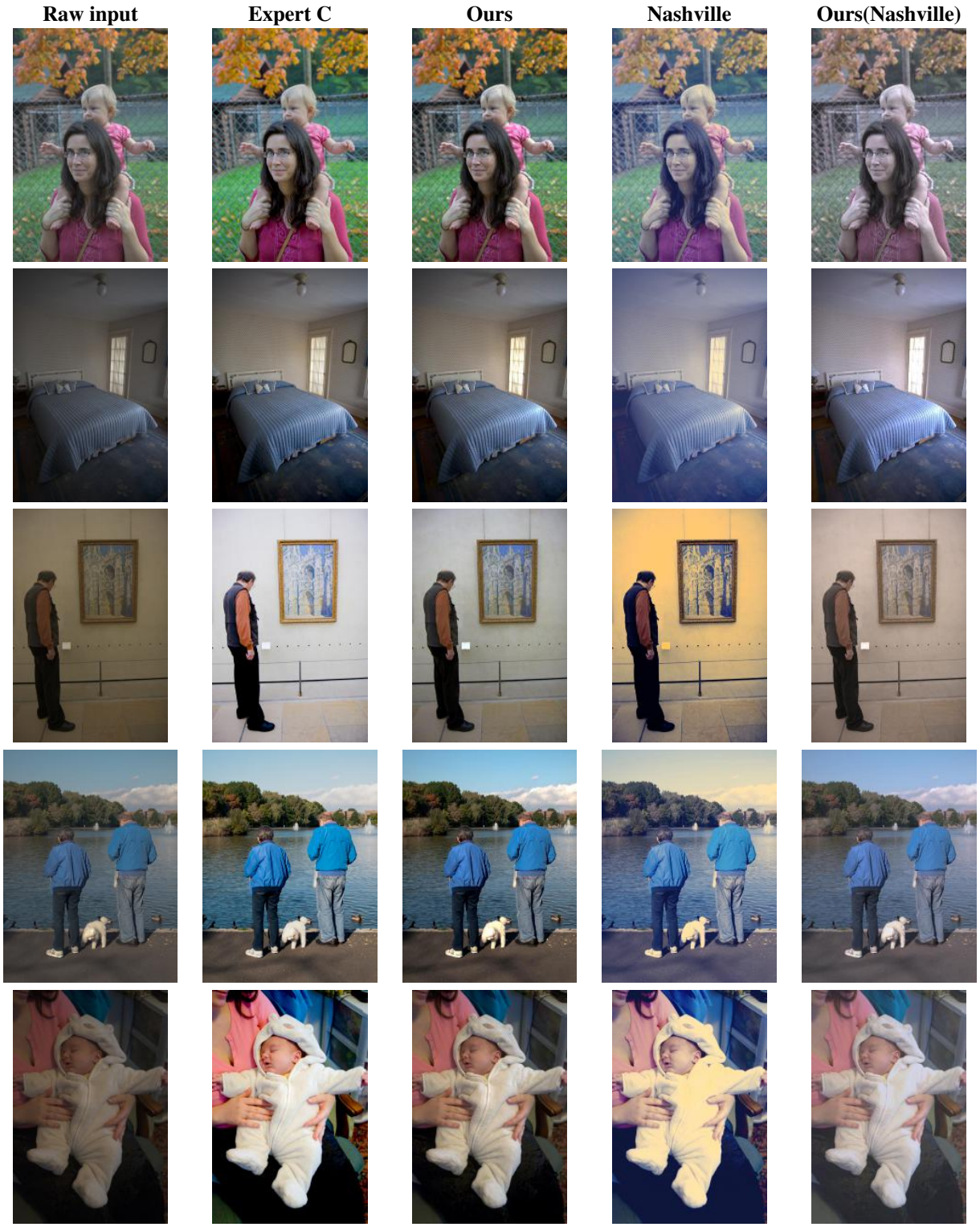


Table 245. [7 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

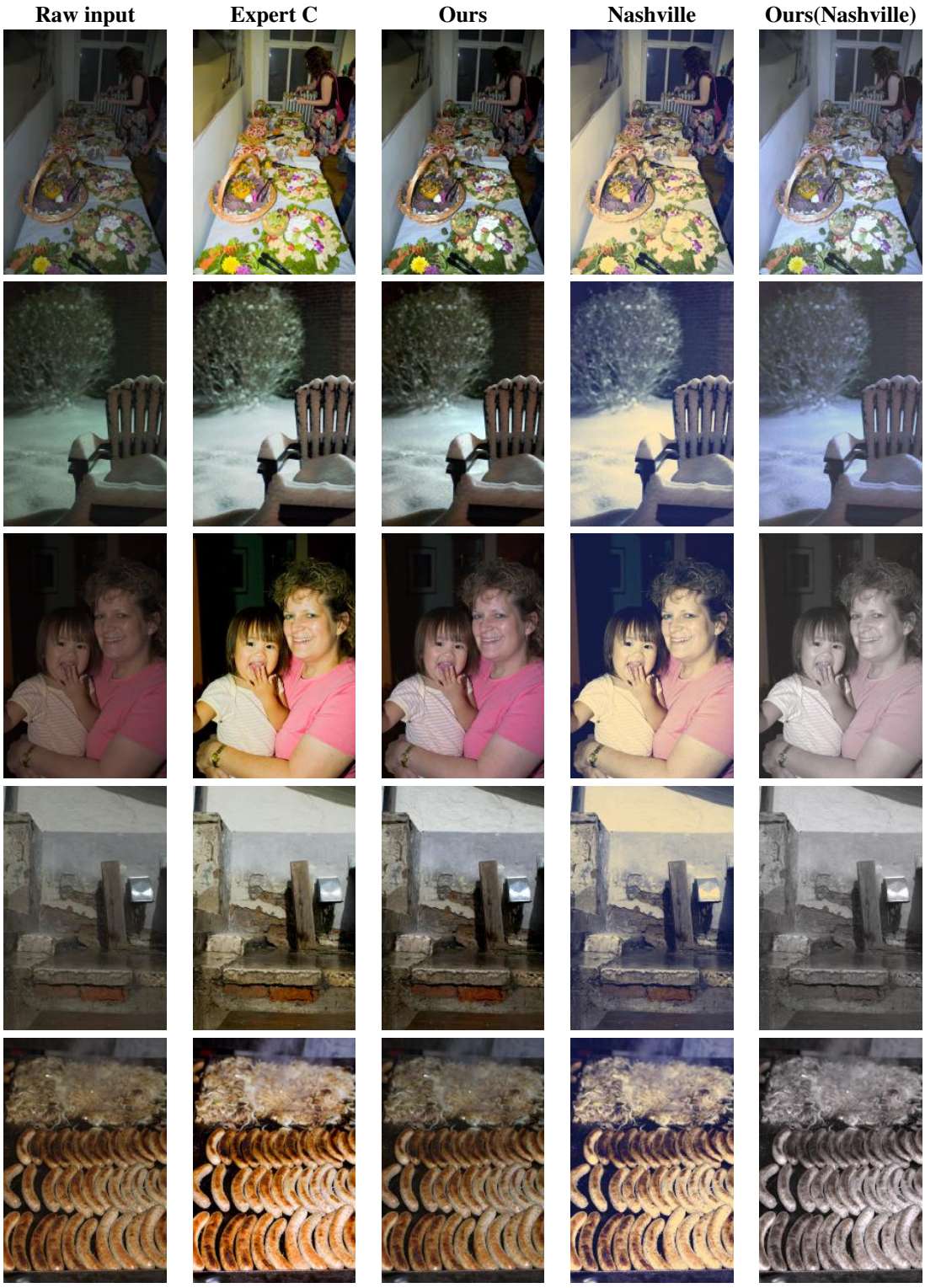


Table 246. [8 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

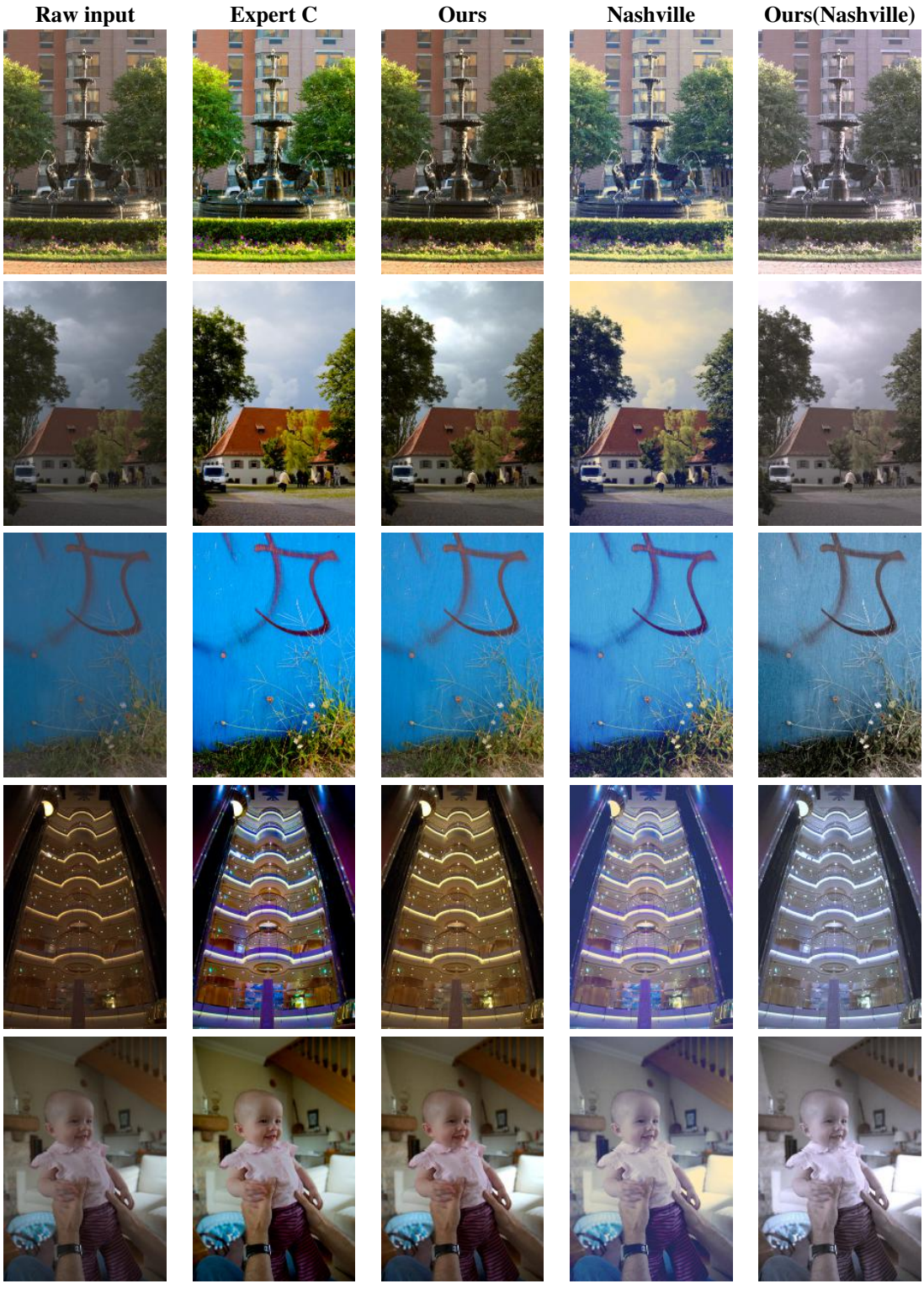


Table 247. [9 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

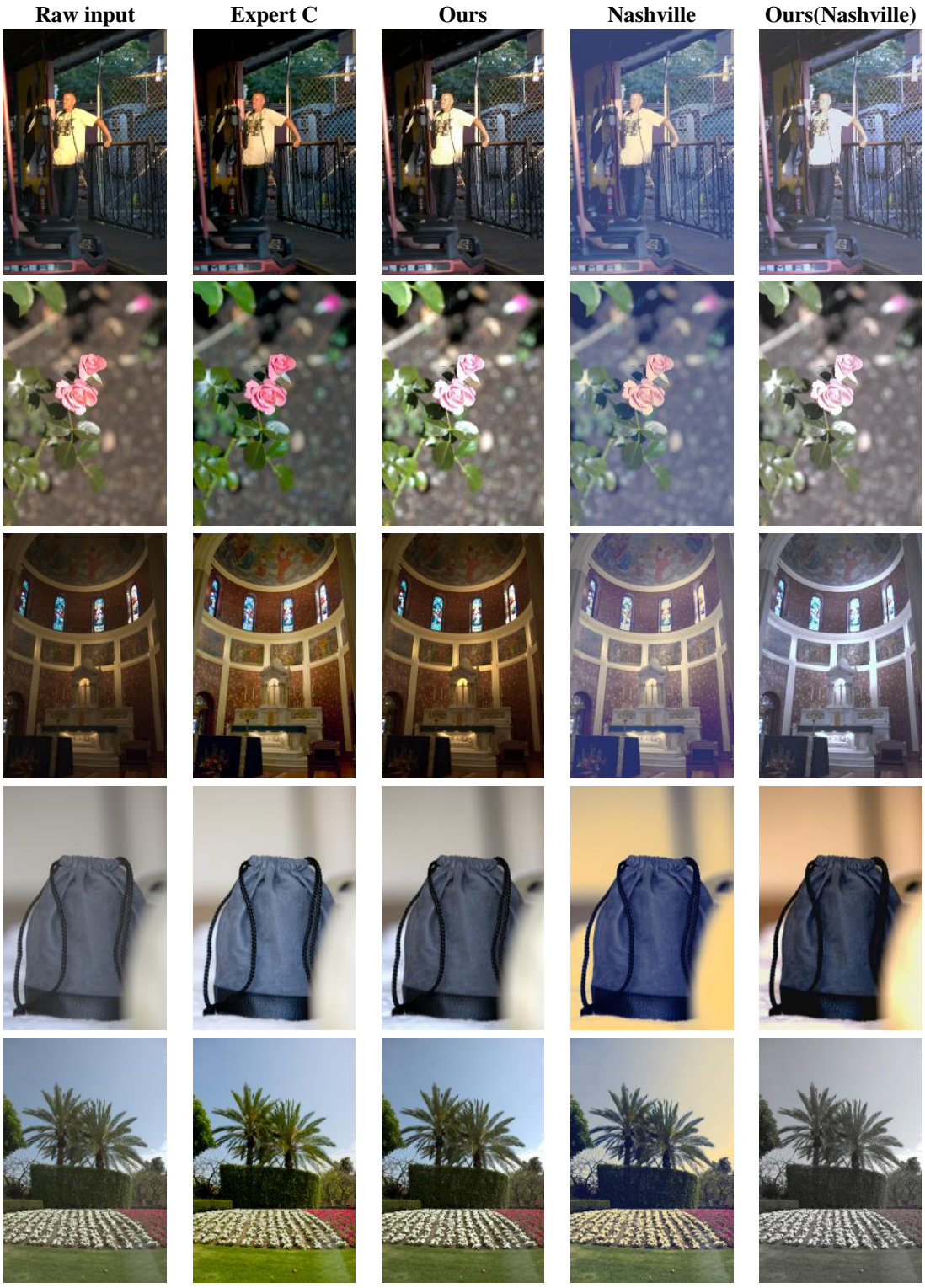


Table 248. [10 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

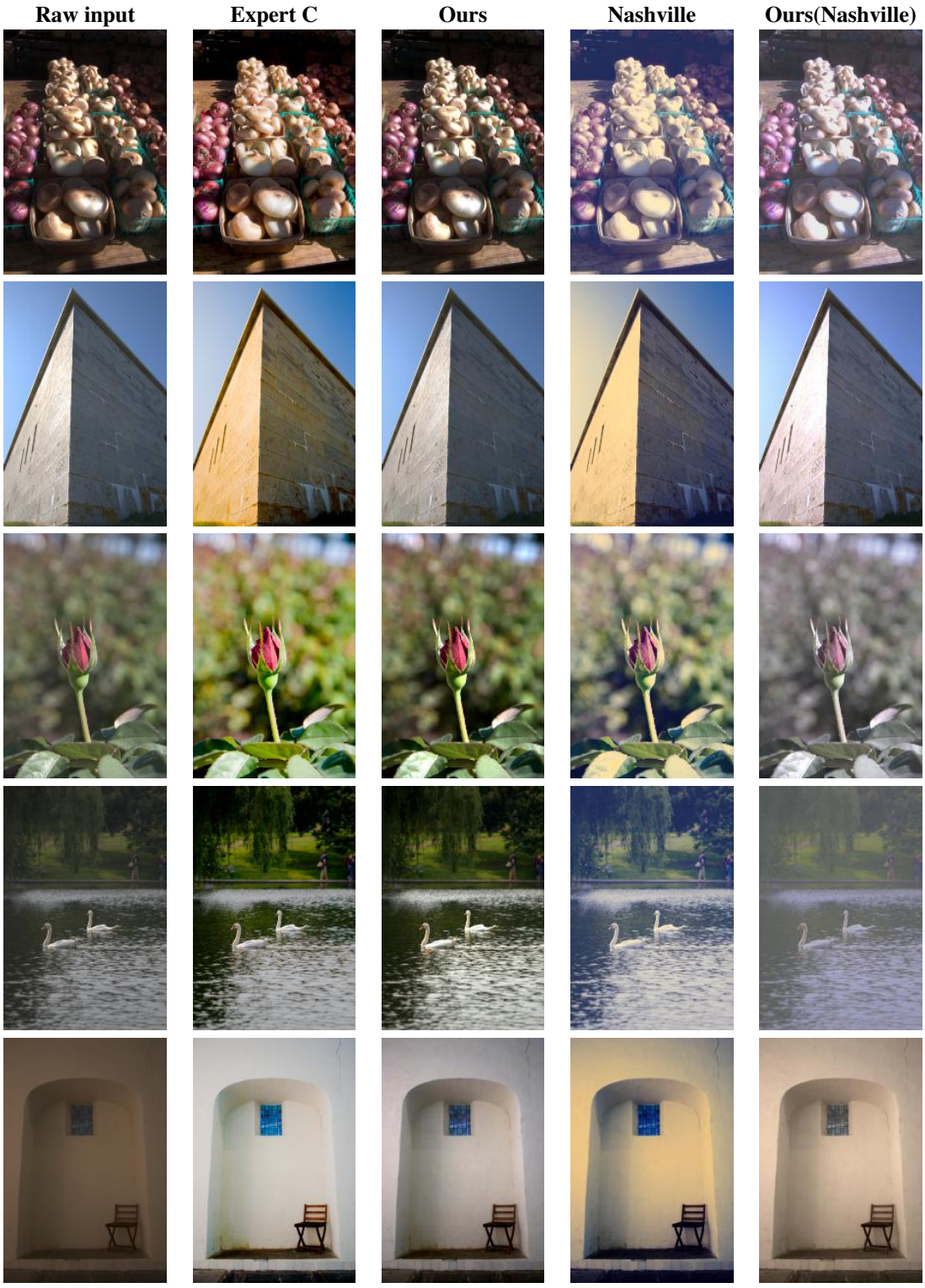


Table 249. [11 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

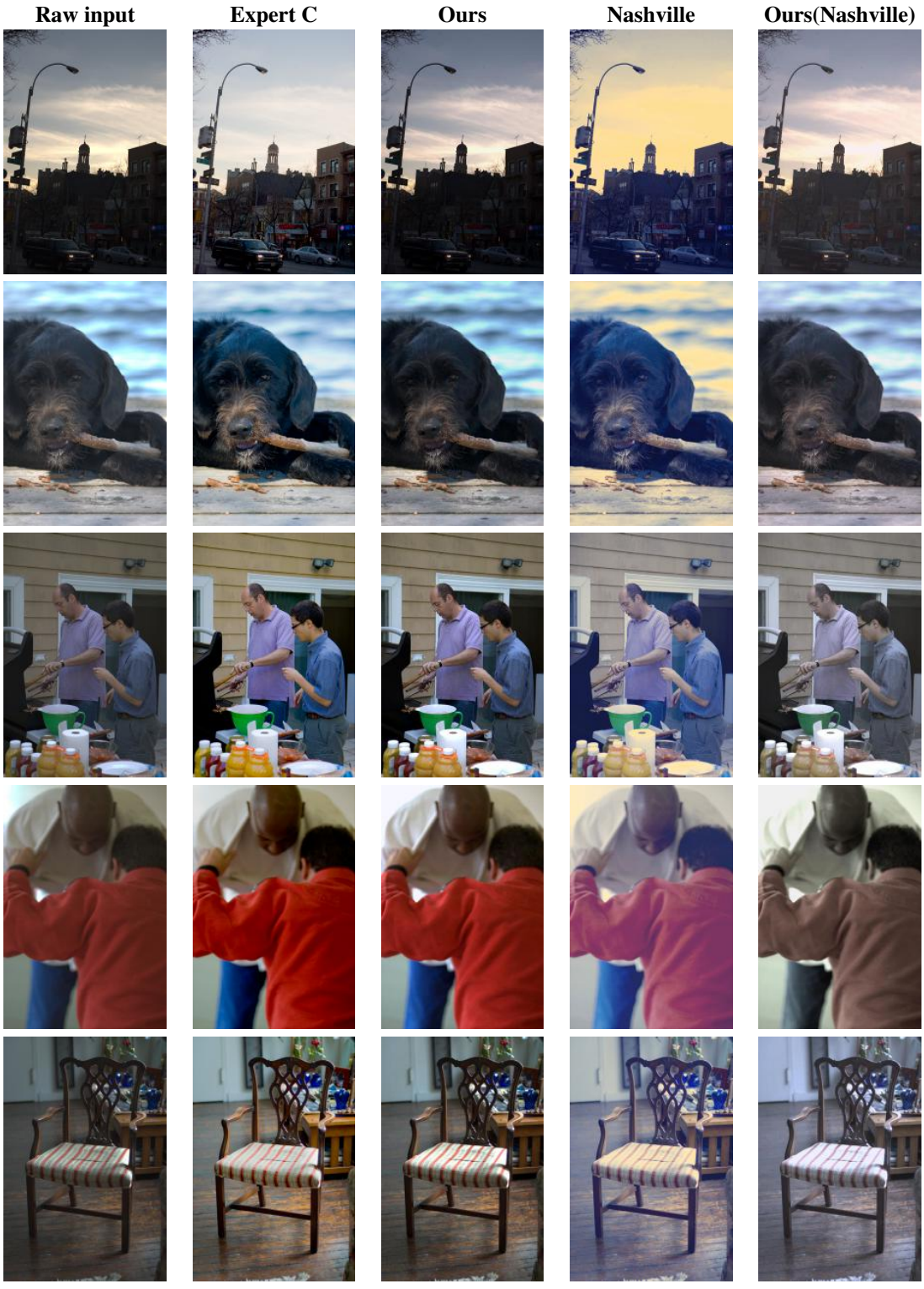


Table 250. [12 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

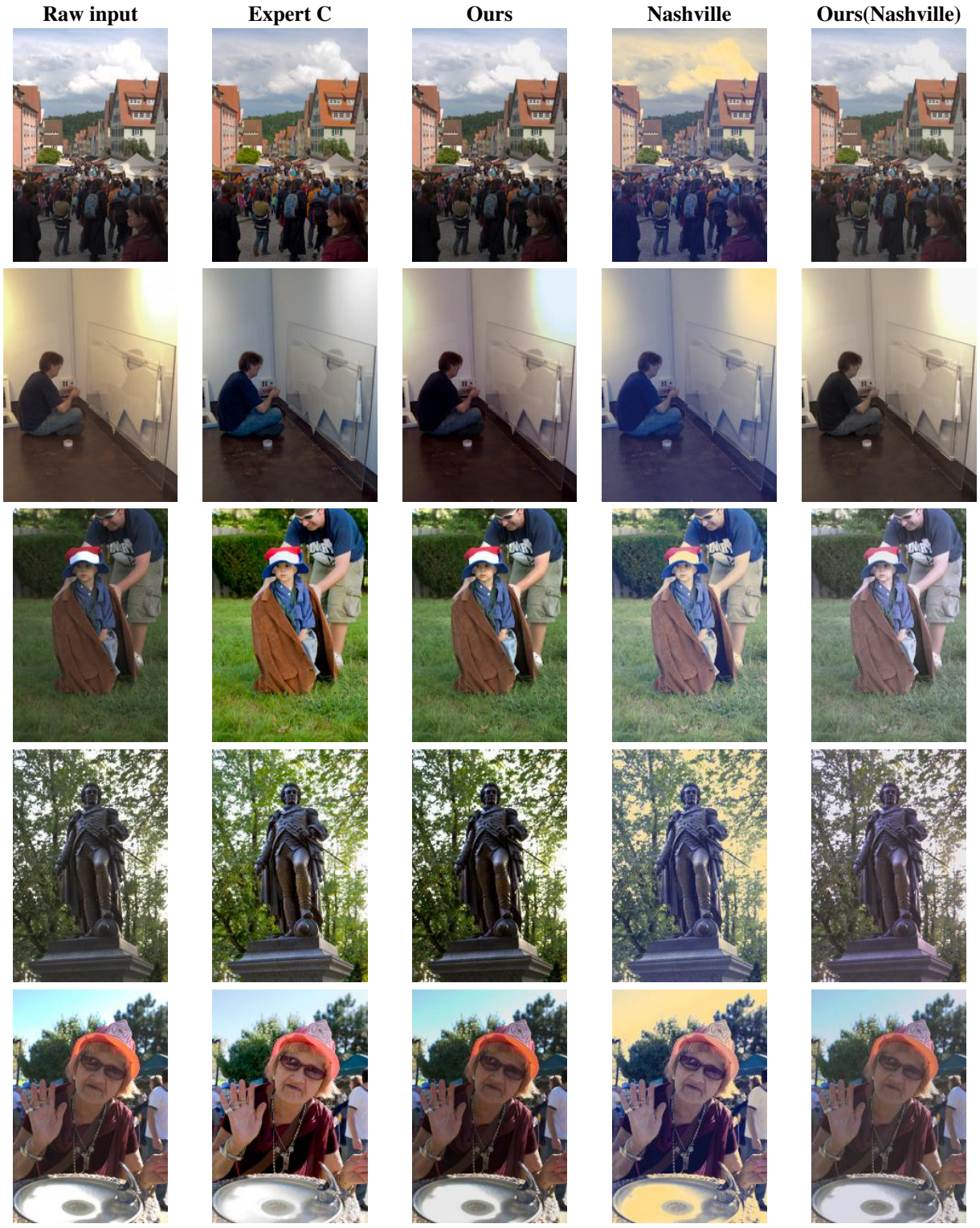


Table 251. [13 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

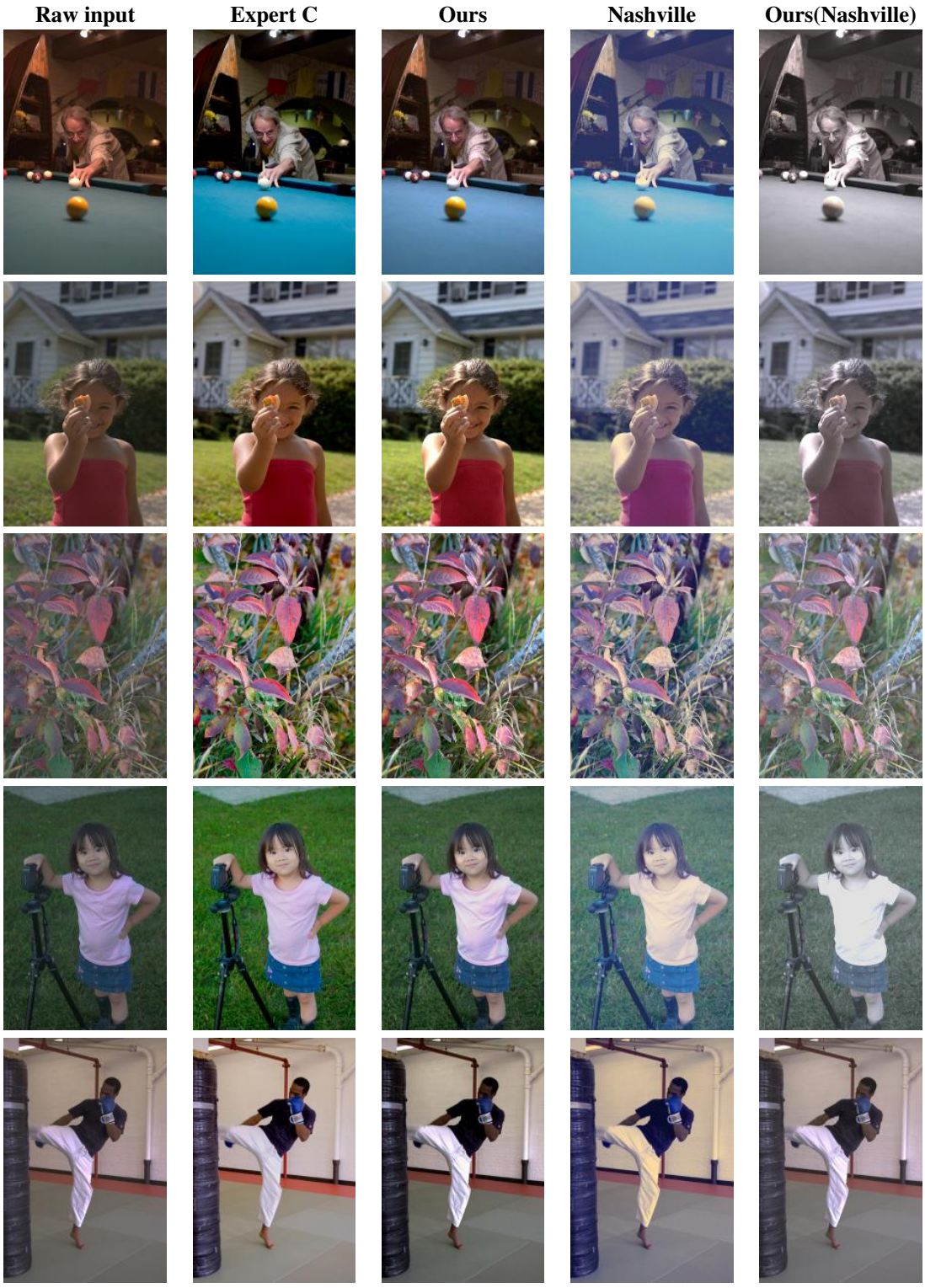


Table 252. [14 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

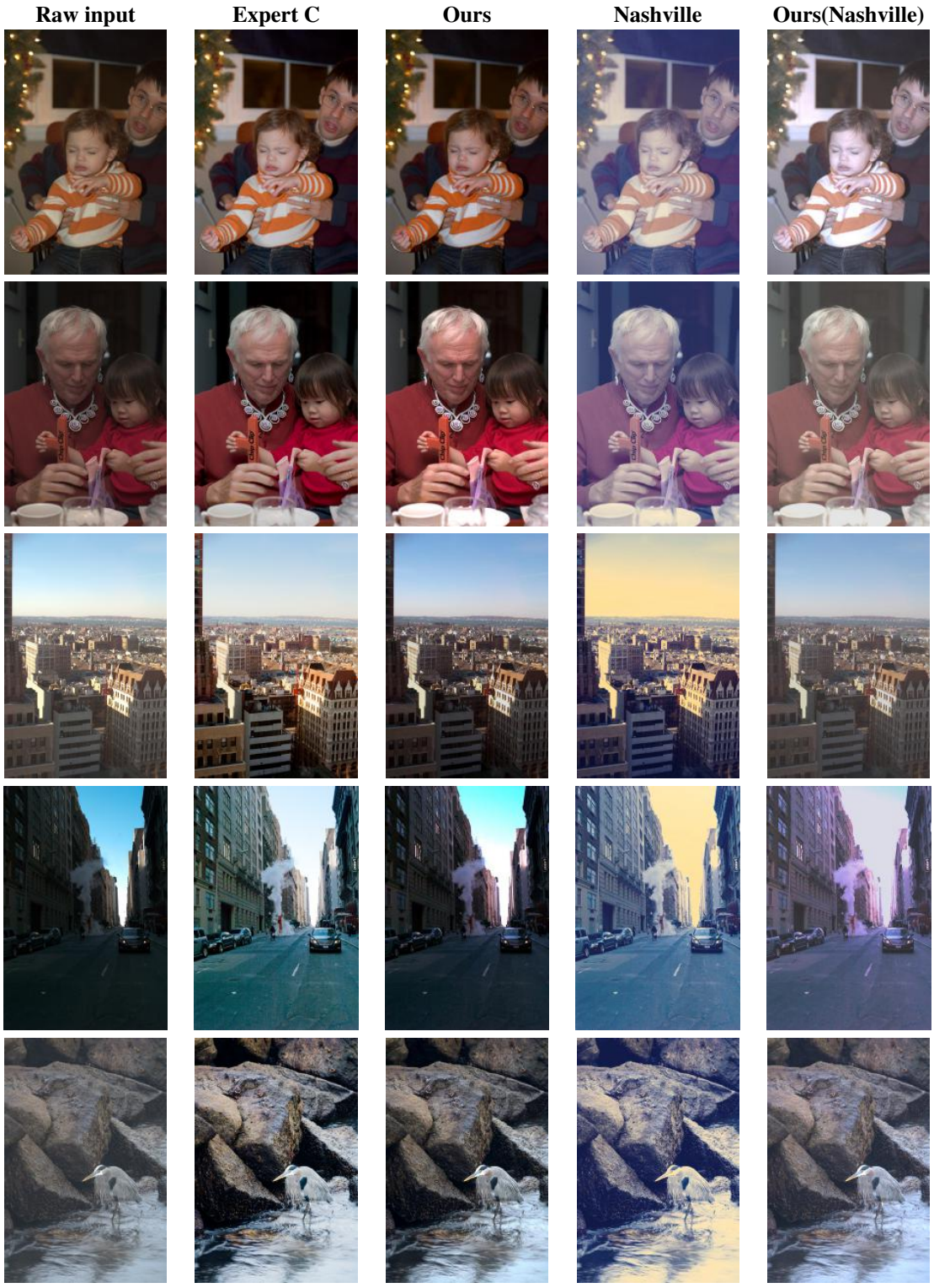


Table 253. [15 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

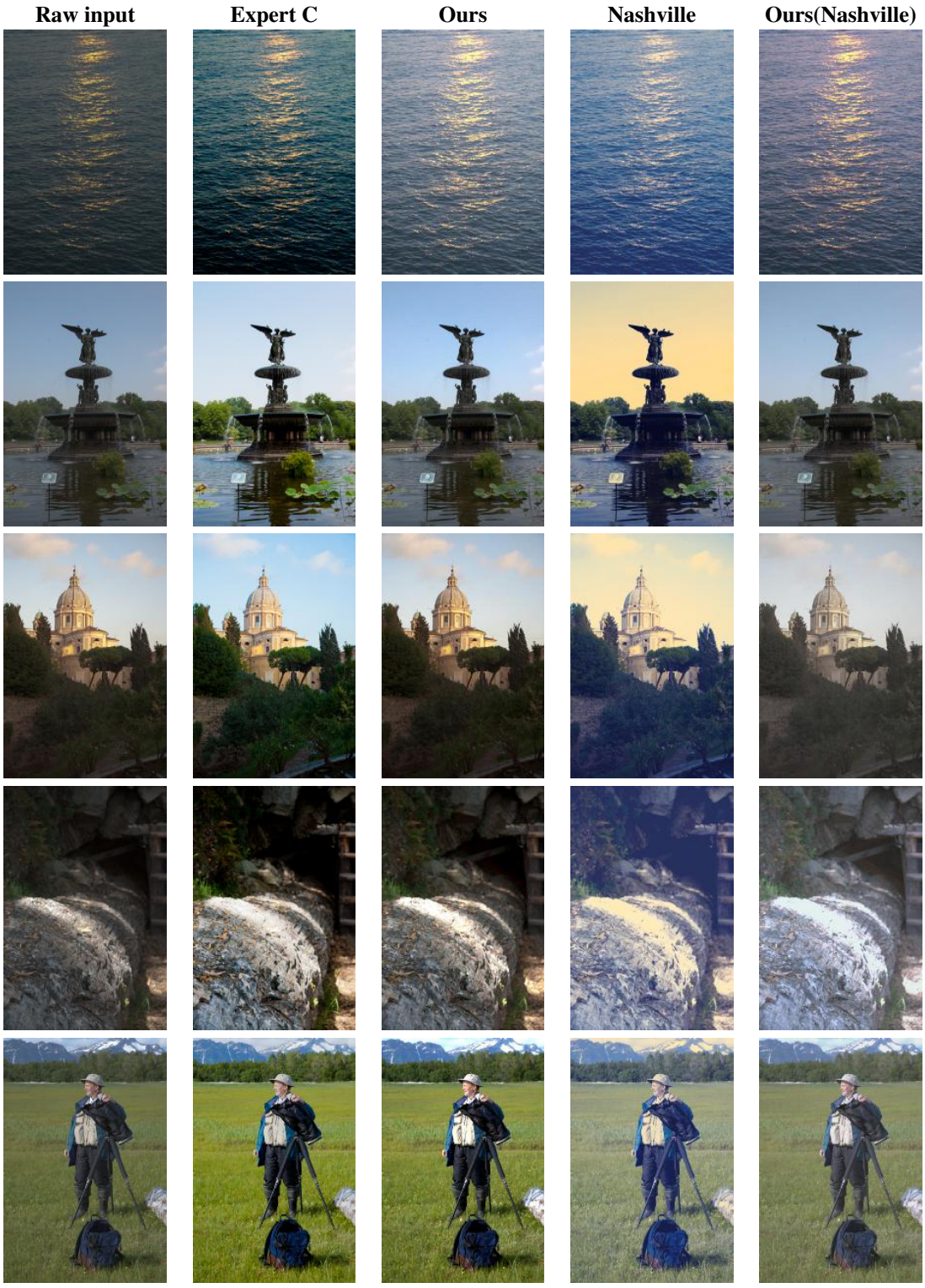


Table 254. [16 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

Table 255. [17 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

Table 256. [18 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

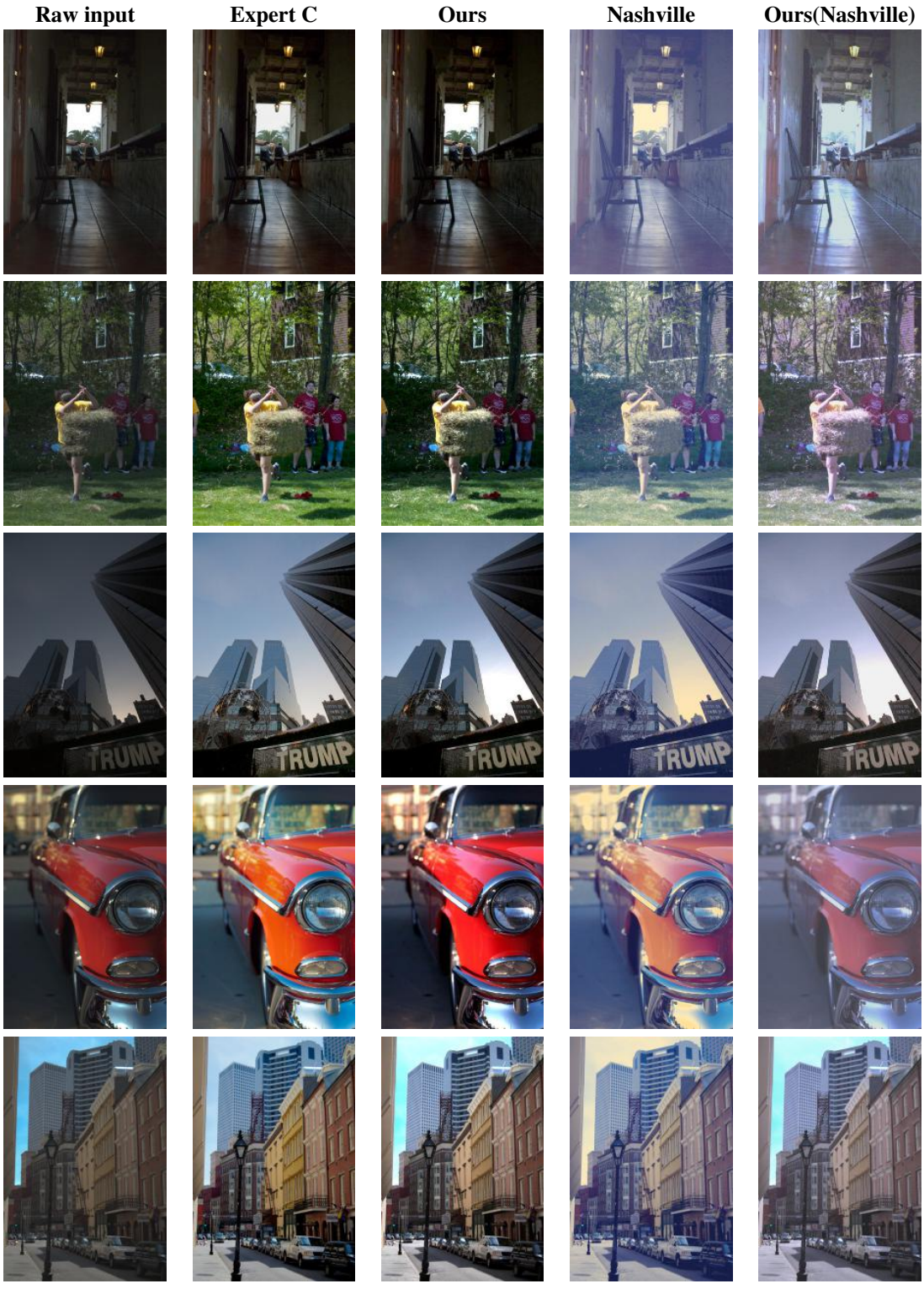


Table 257. [19 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

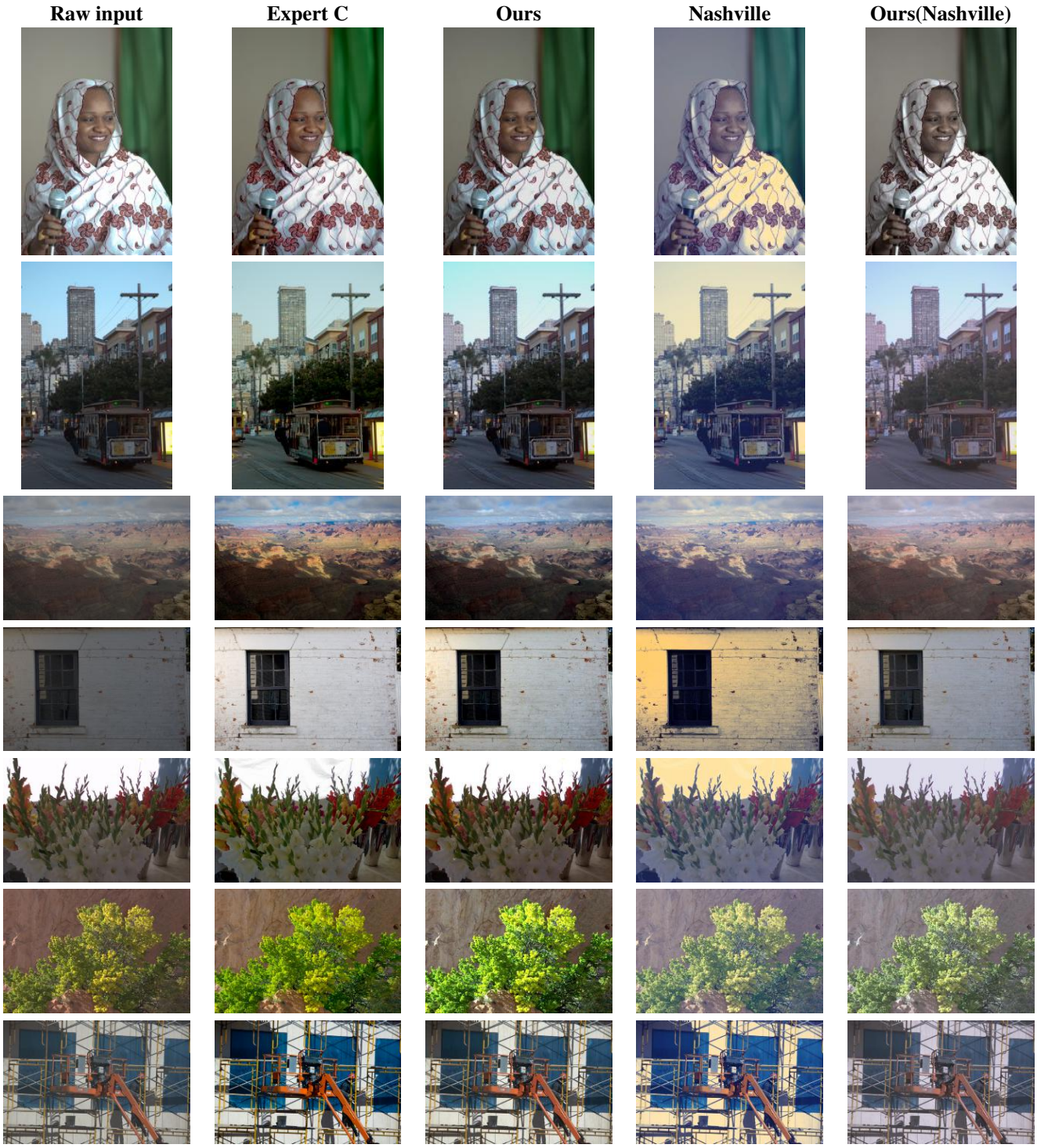


Table 258. [20 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

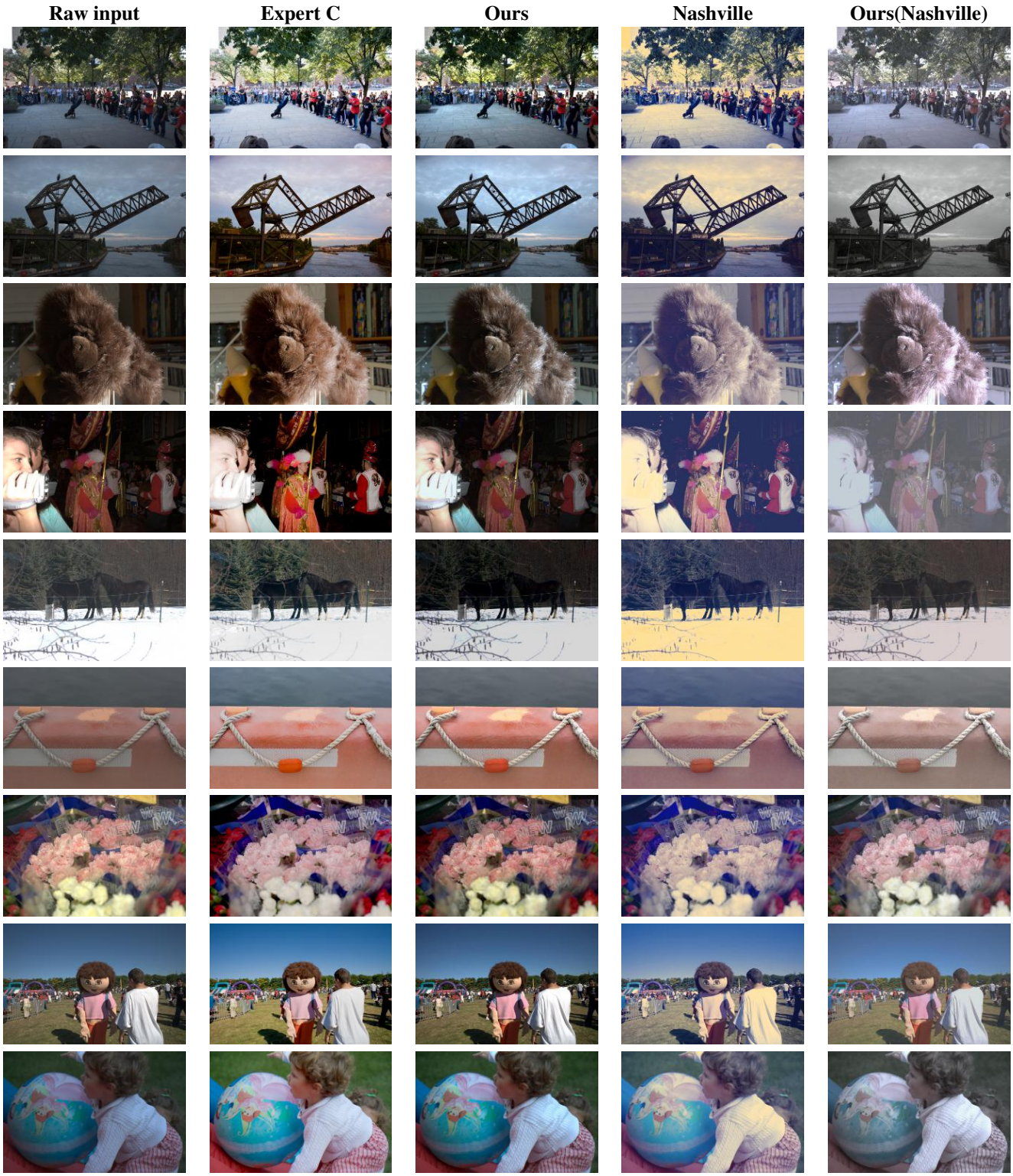


Table 259. [21 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

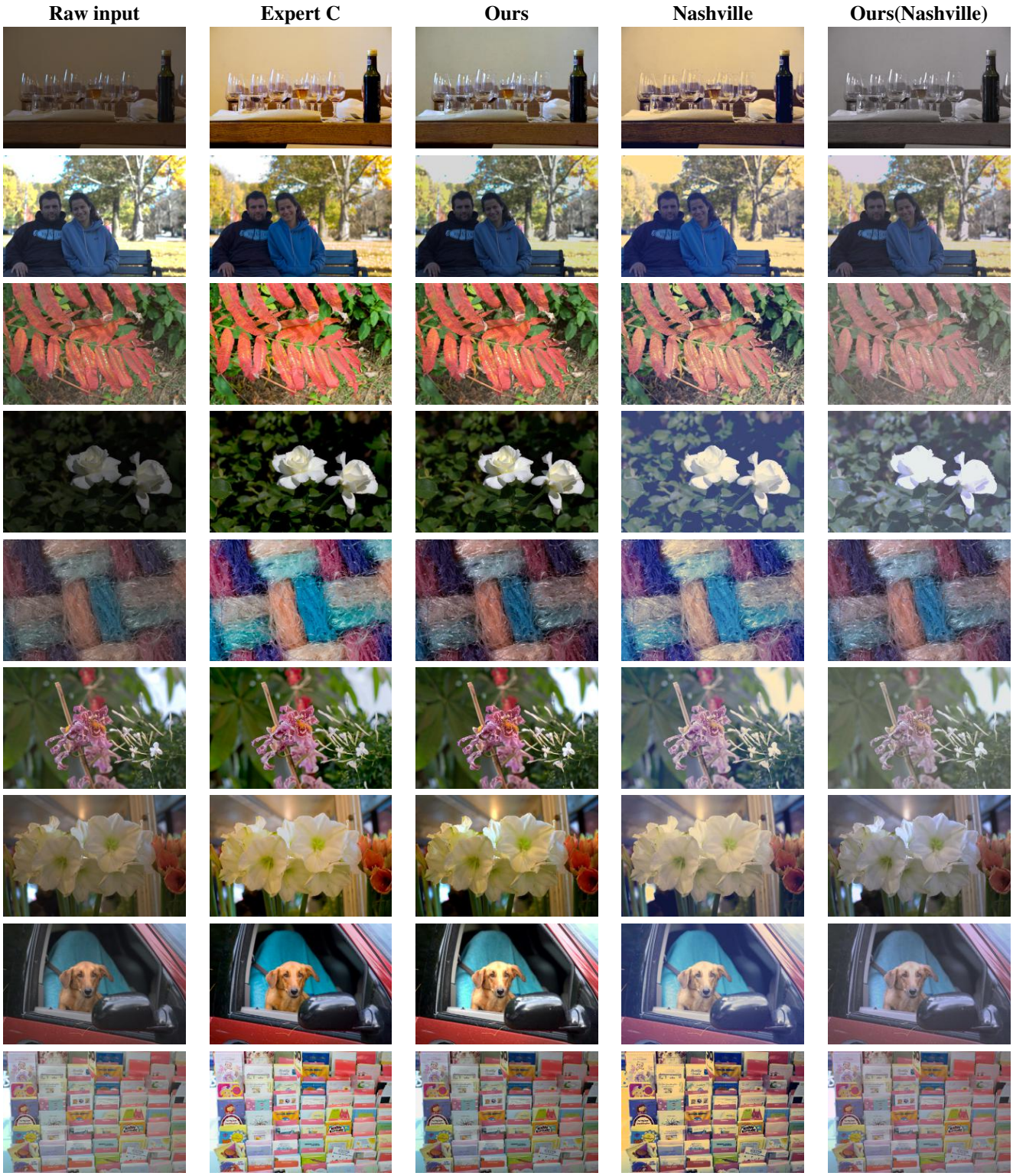


Table 260. [22 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

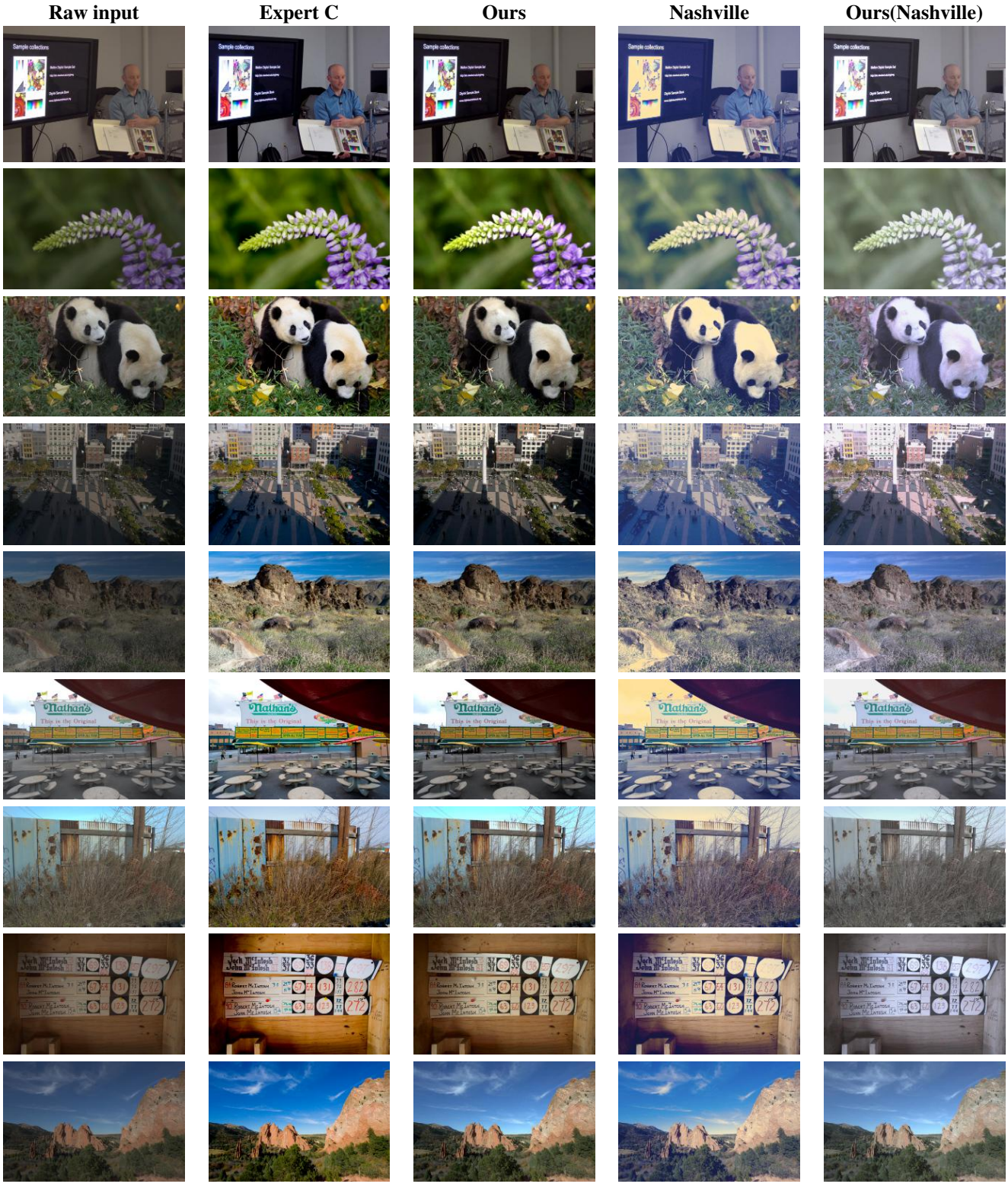


Table 261. [23 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

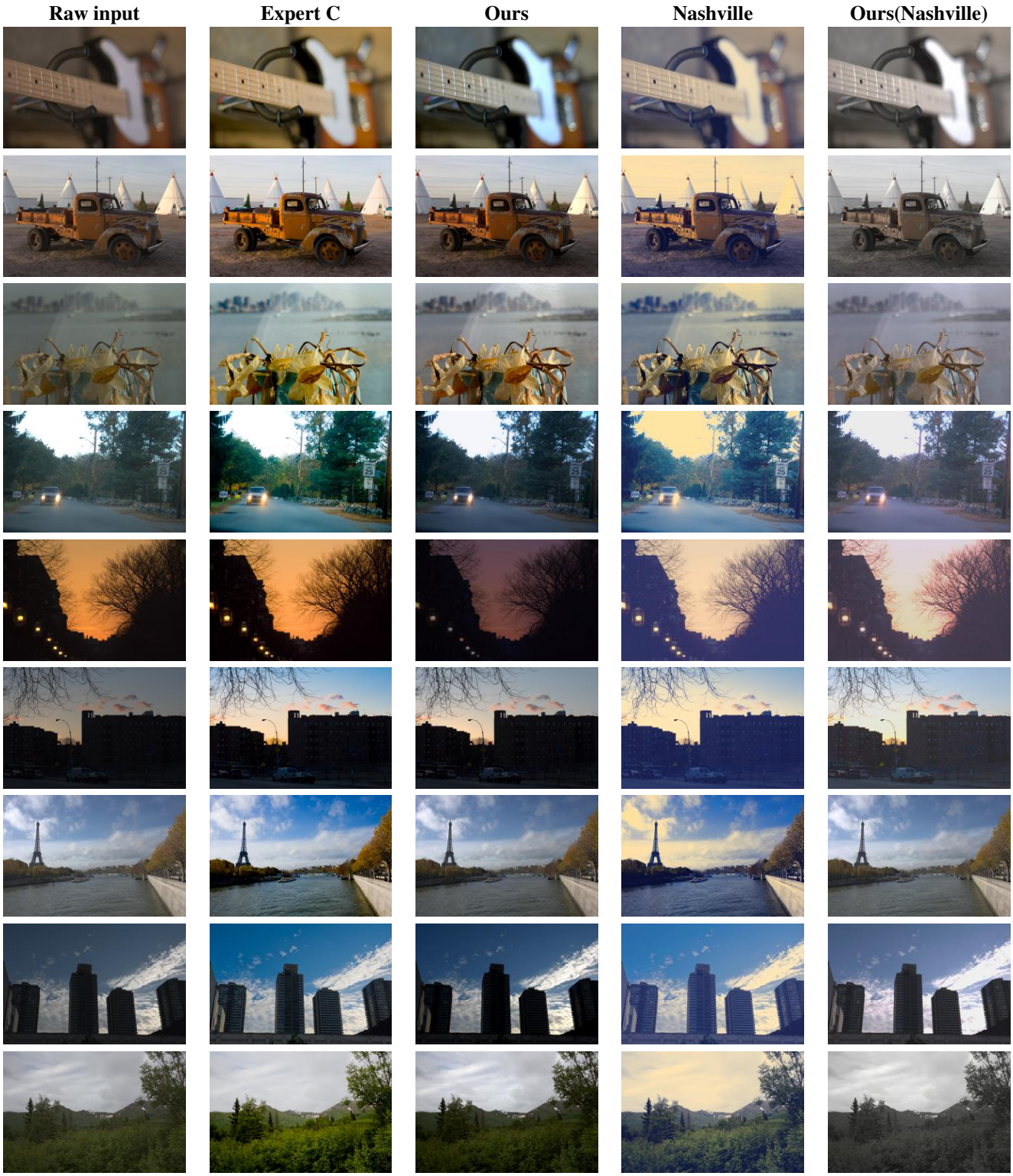


Table 262. [24 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

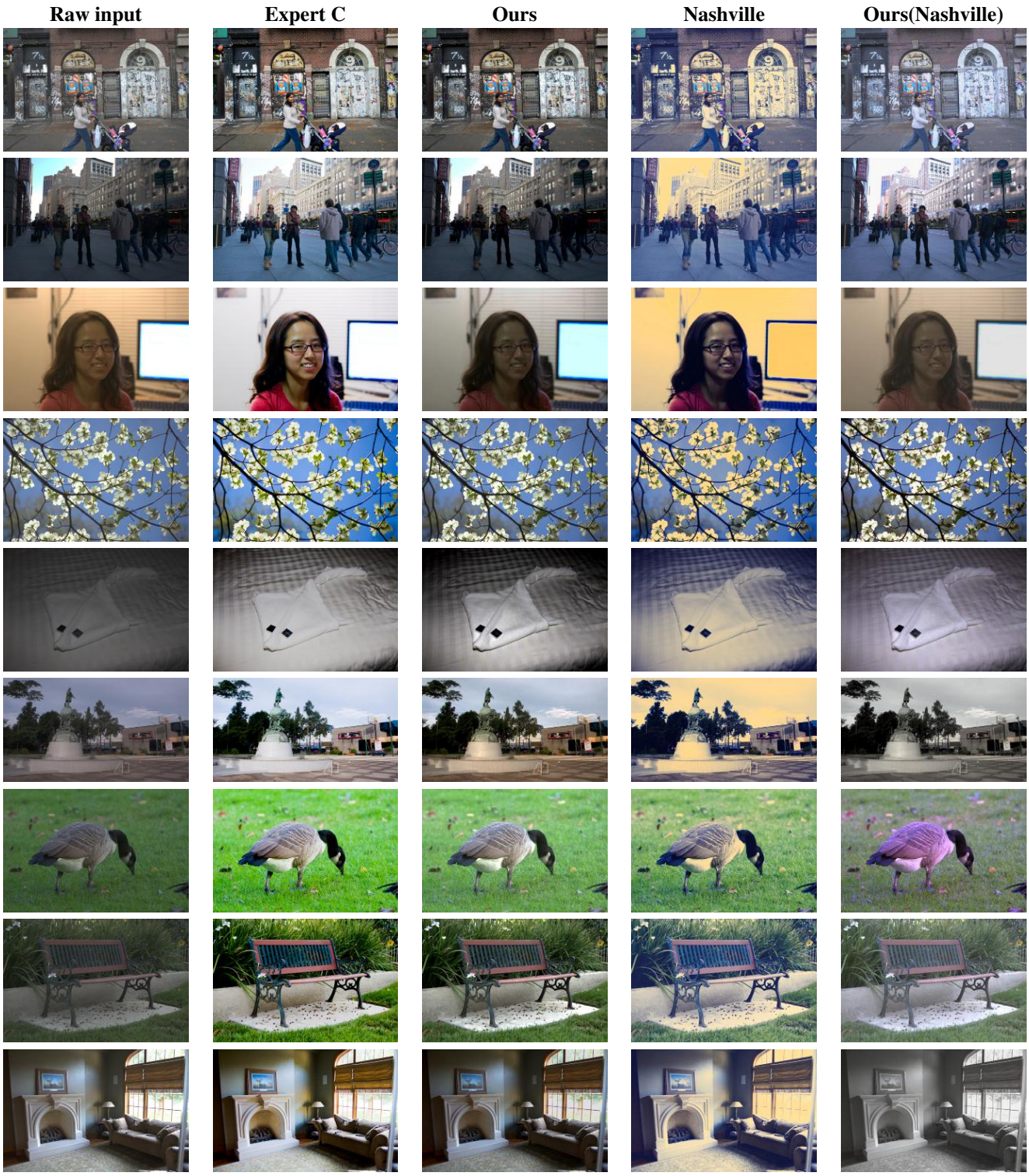


Table 263. [25 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

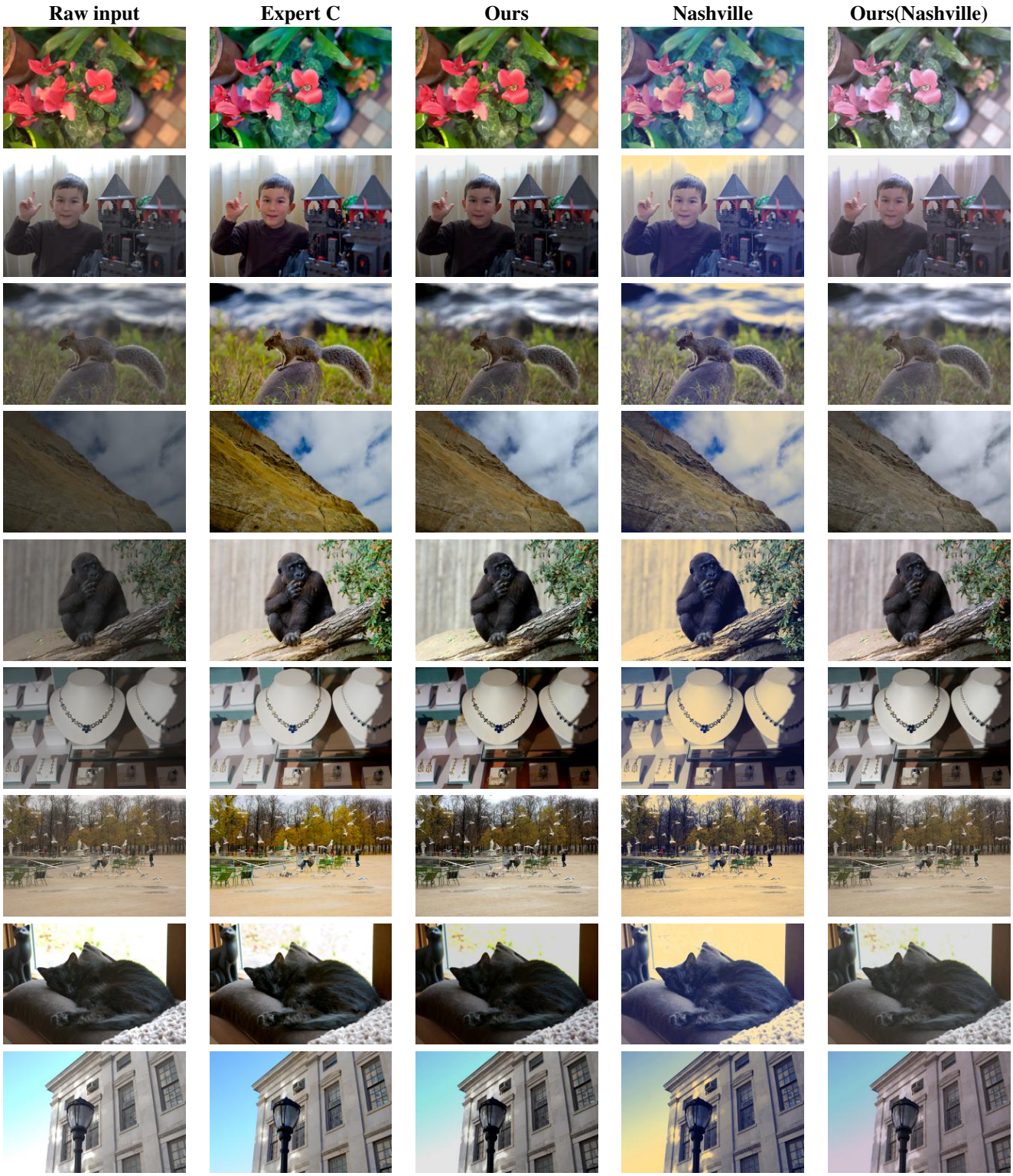


Table 264. [26 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

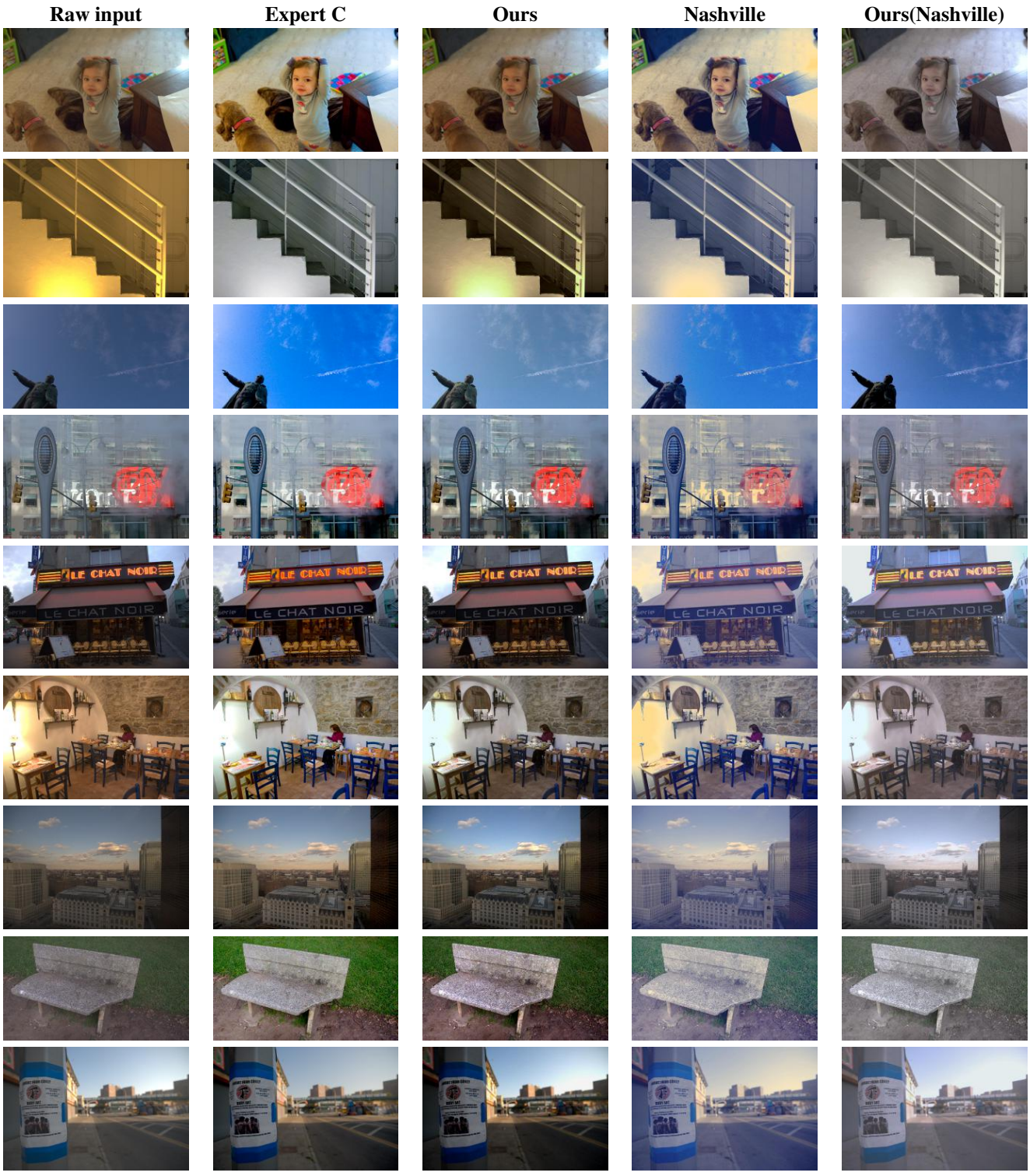


Table 265. [27 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

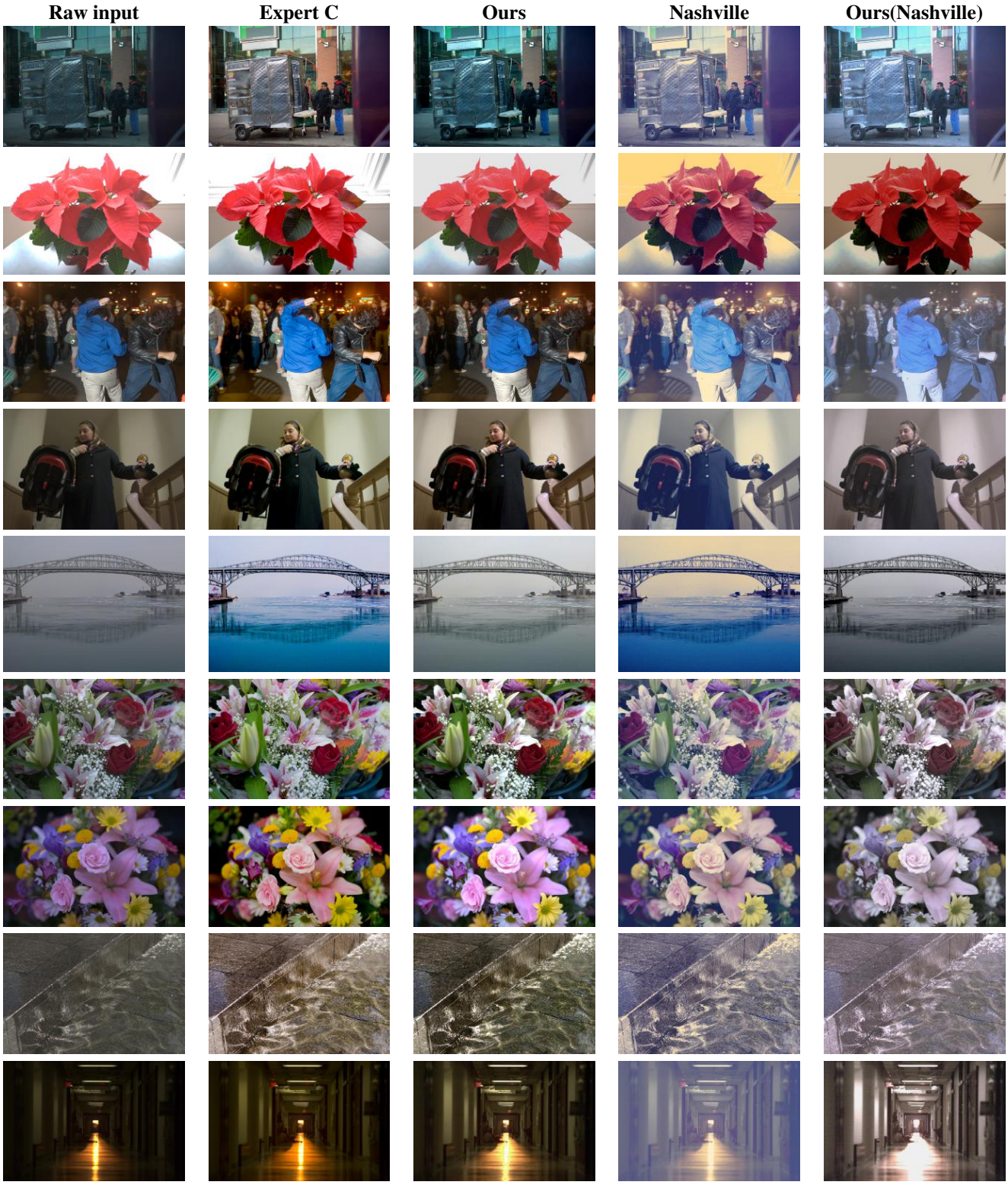


Table 266. [28 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

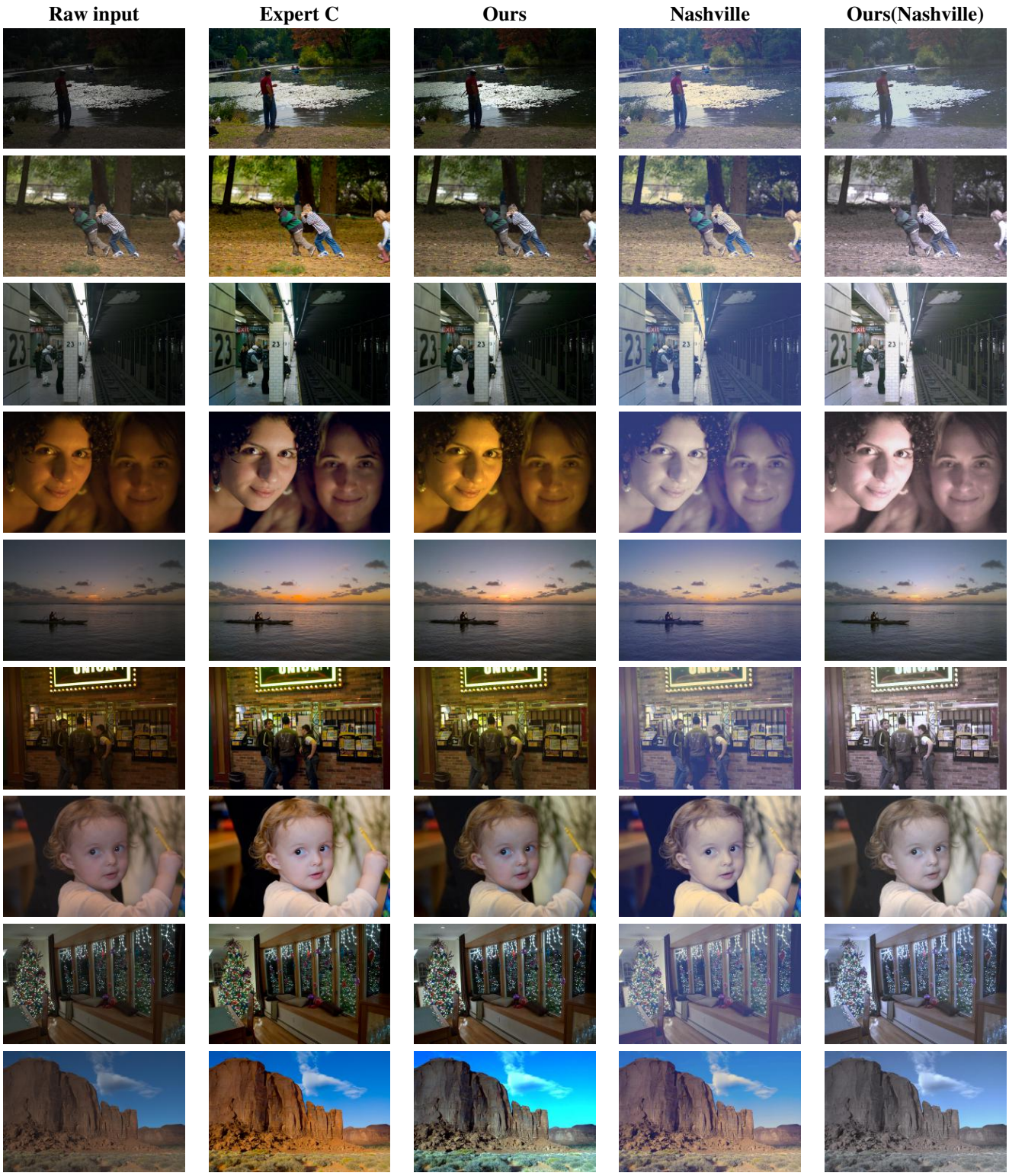


Table 267. [29 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

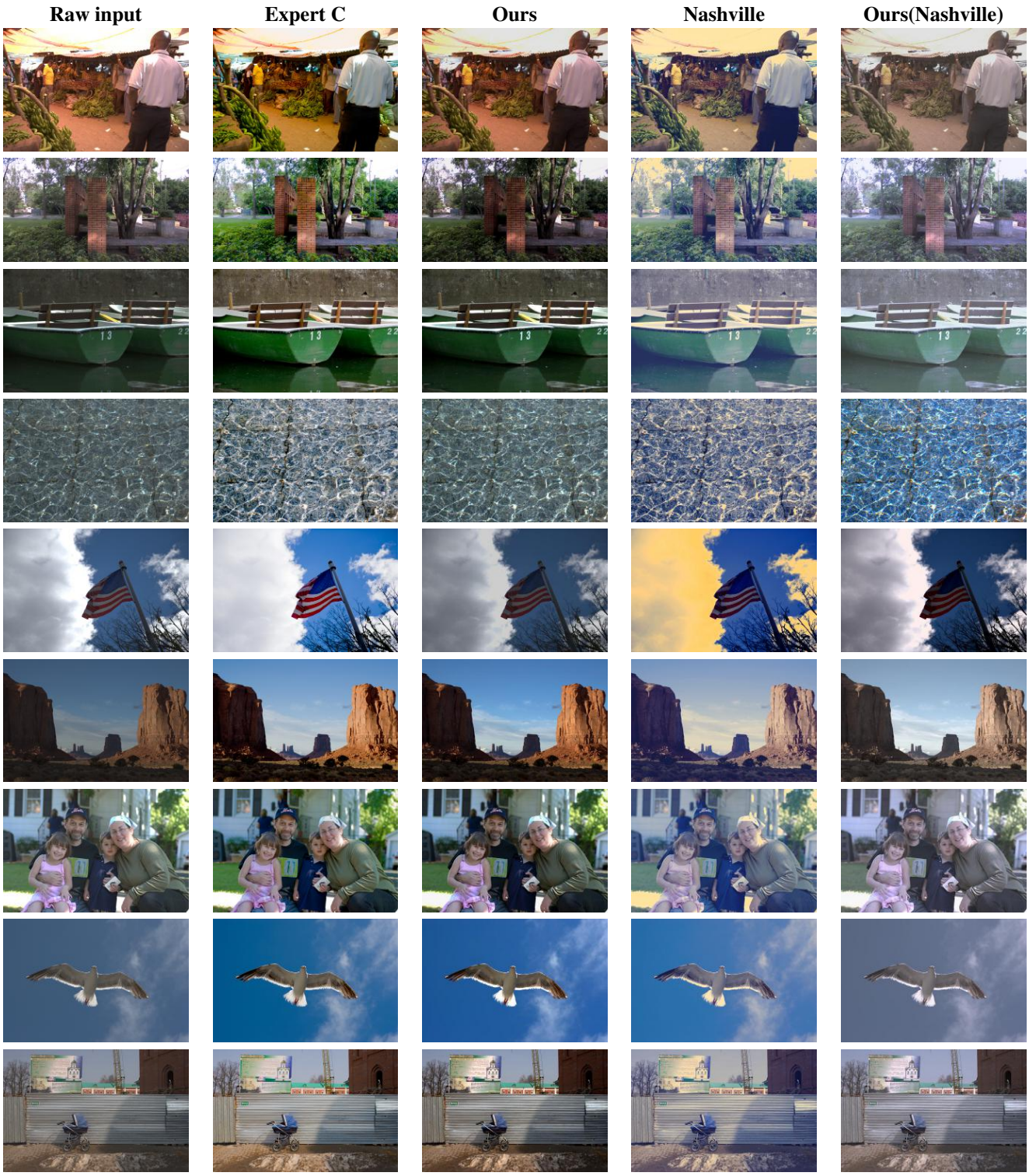


Table 268. [30 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

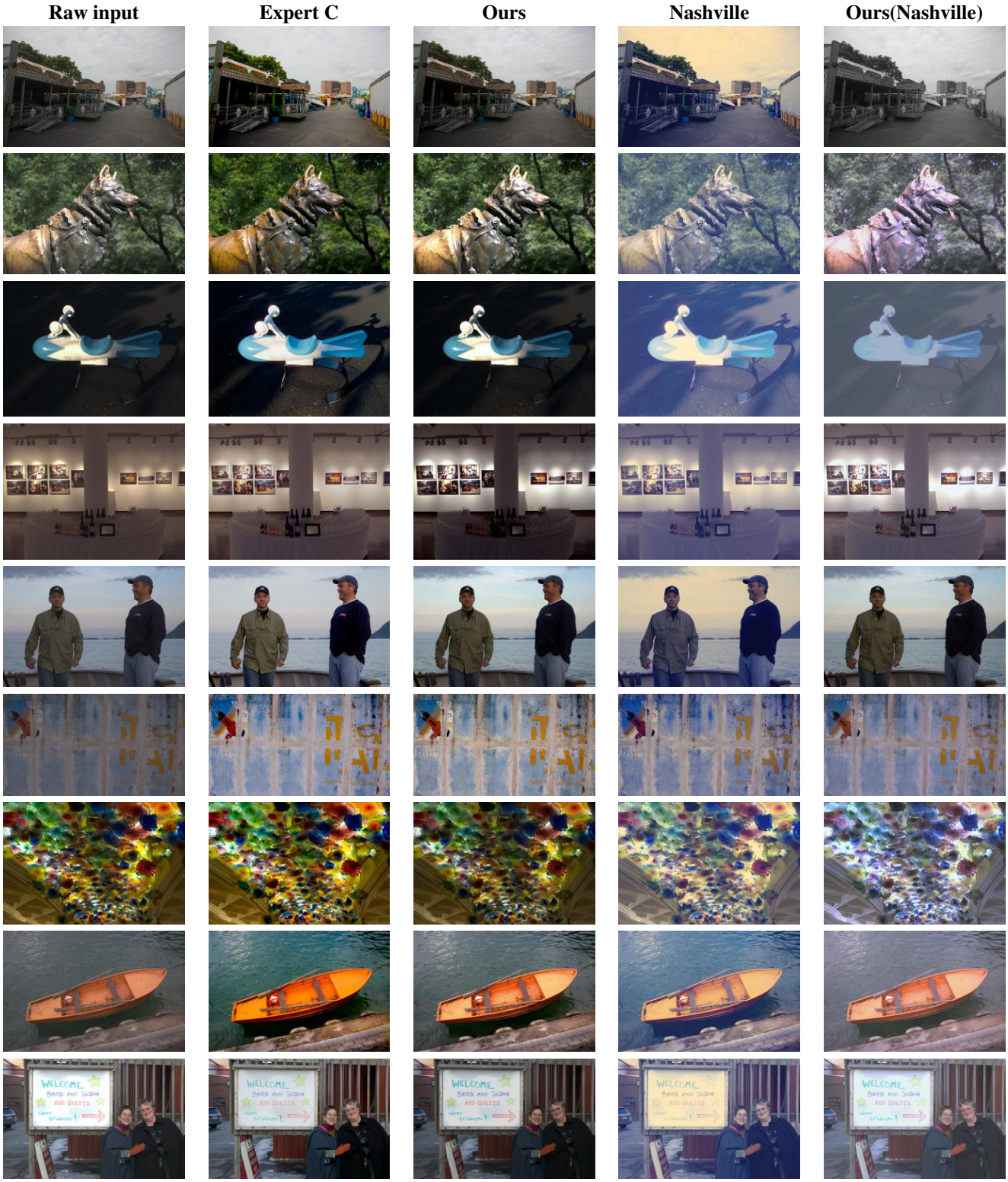


Table 269. [31 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

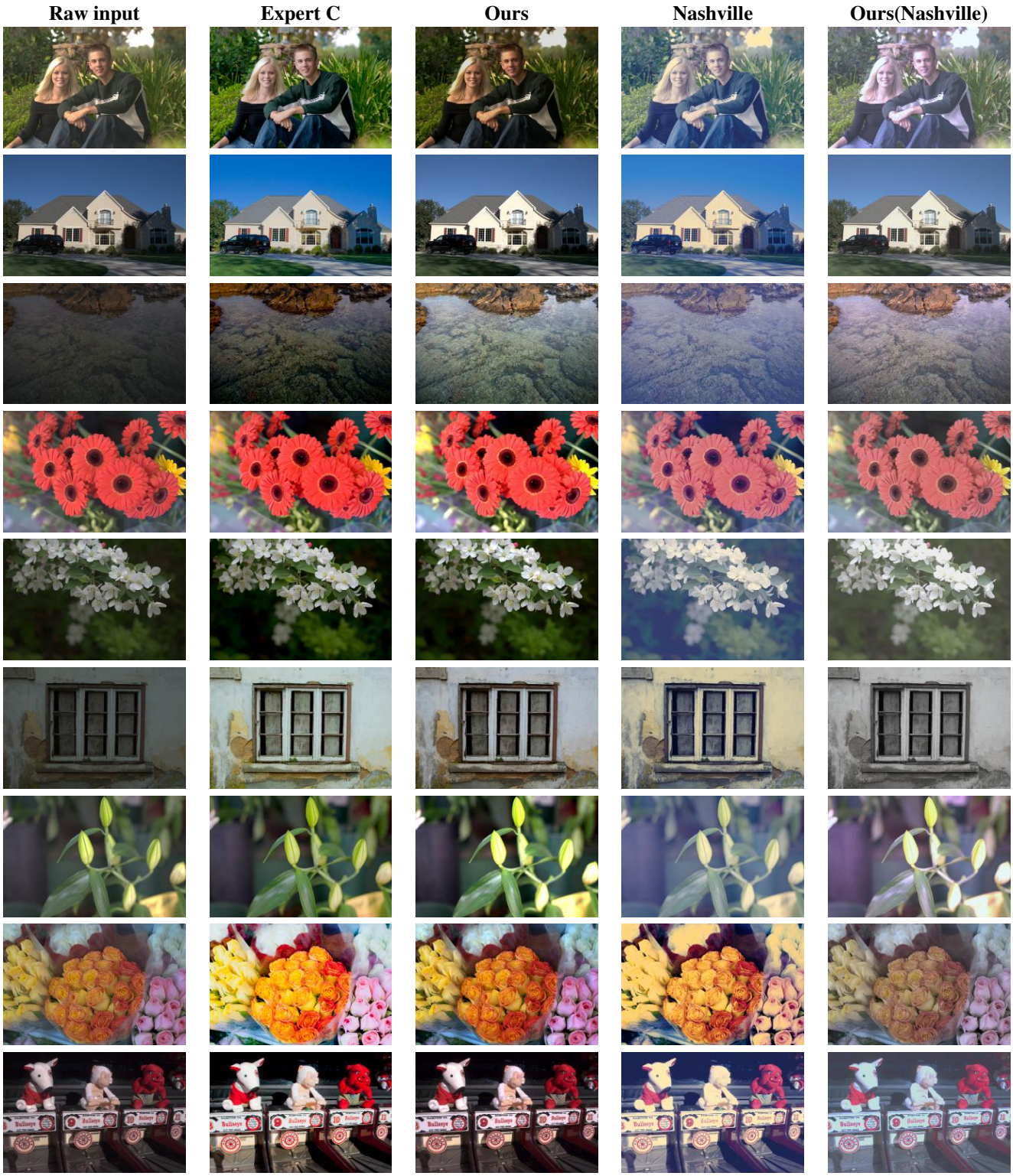


Table 270. [32 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

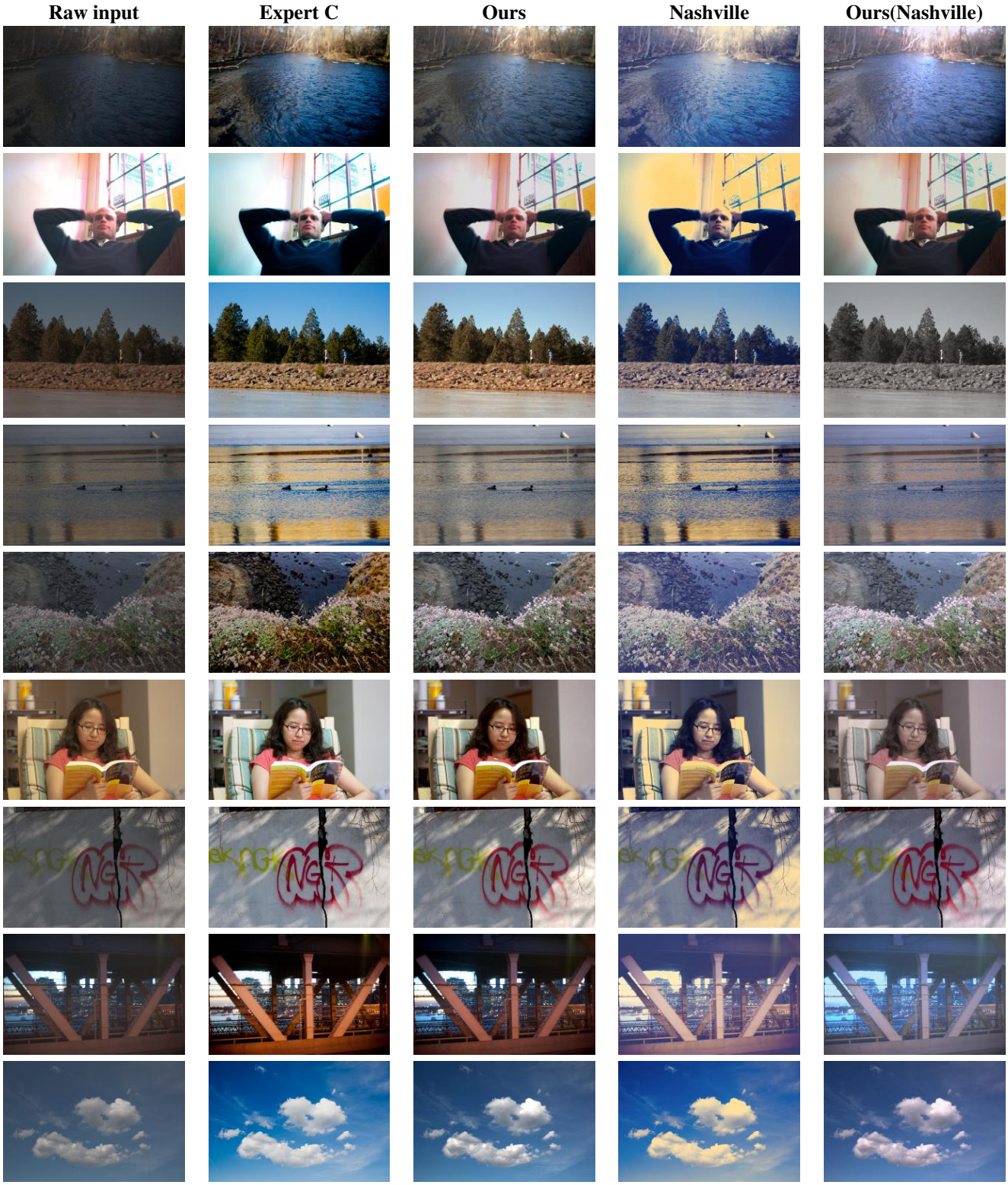


Table 271. [33 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

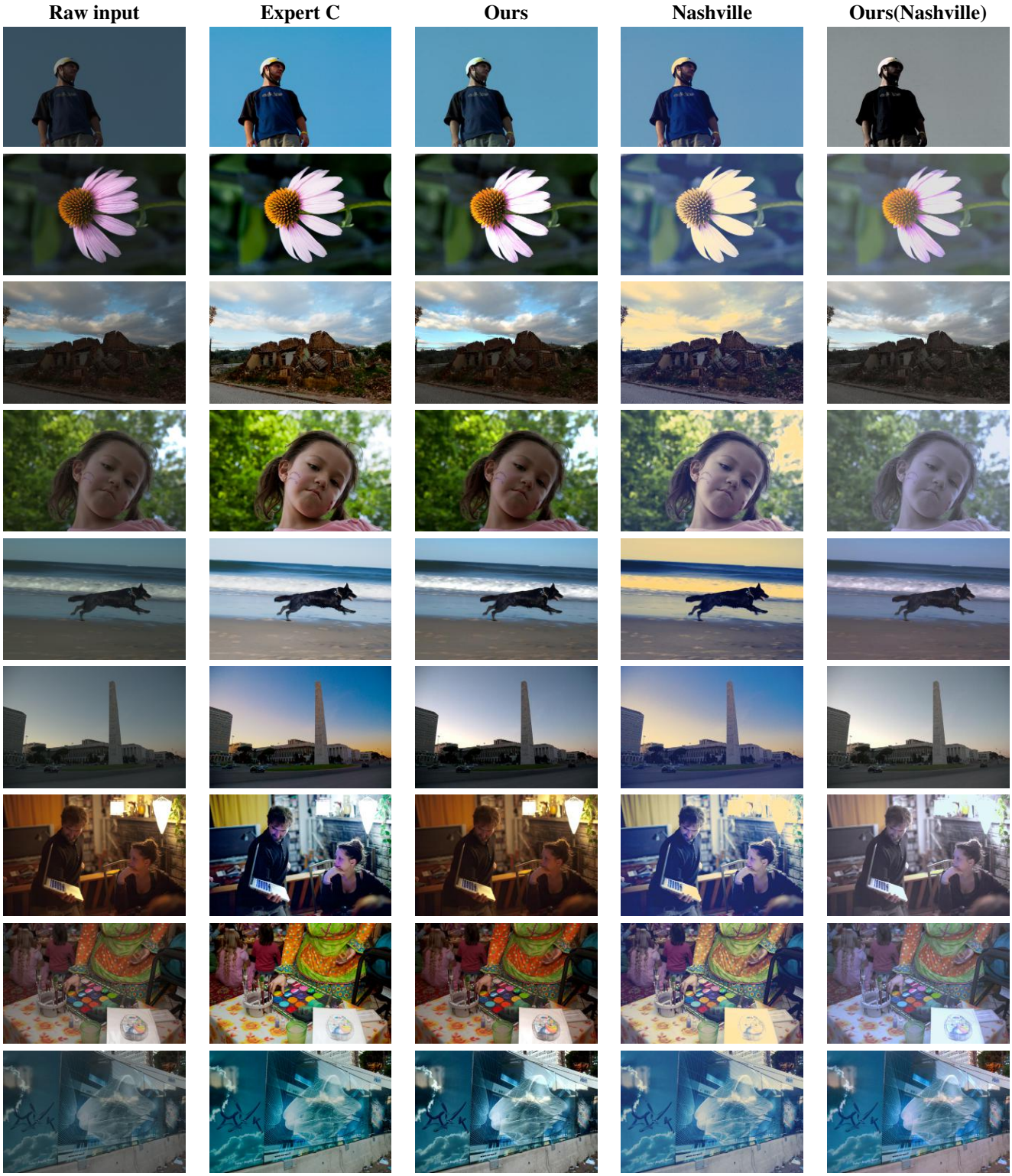


Table 272. [34 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

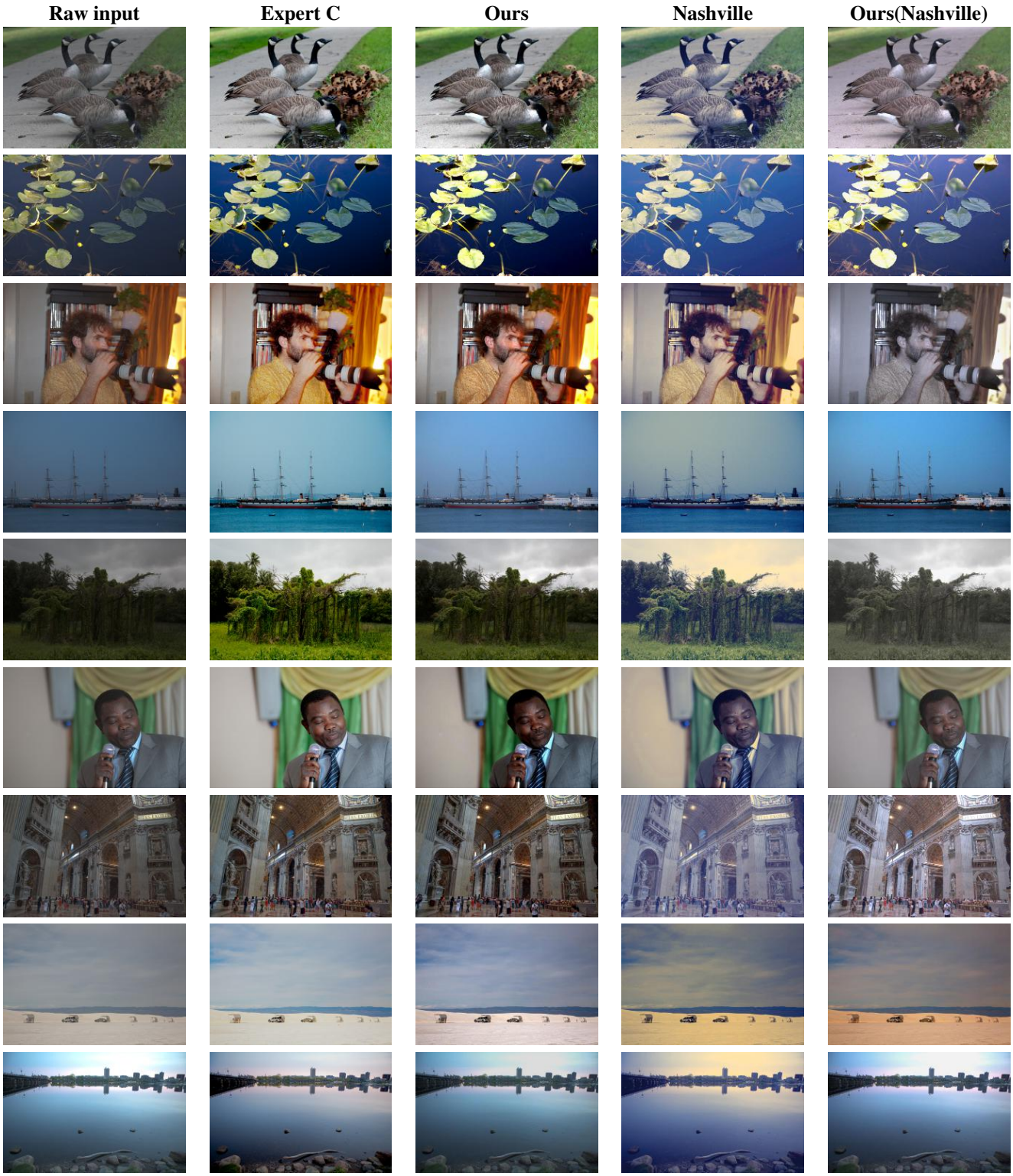


Table 273. [35 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

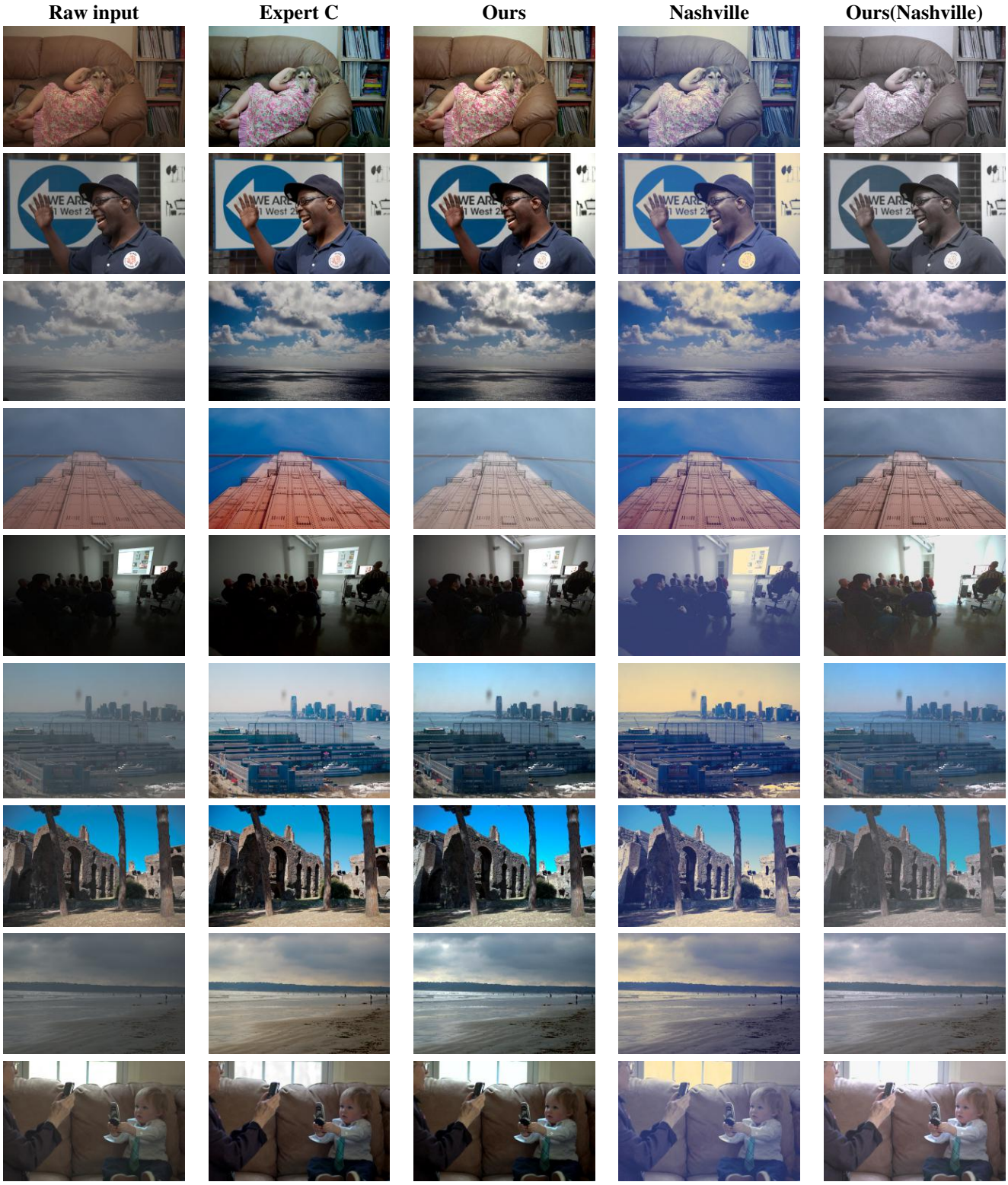


Table 274. [36 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

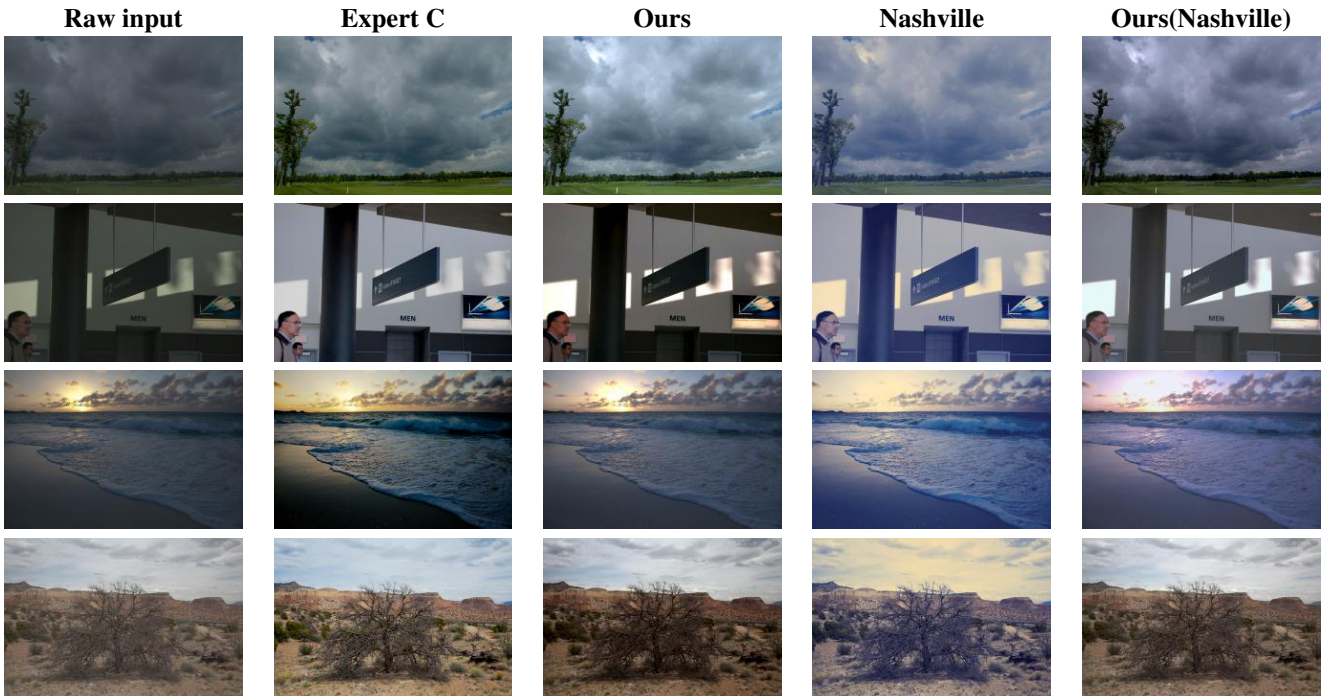


Table 275. [37 / 37] Experiment result using distort-and-recover training scheme on Nashville-filtered reference images

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[1] P. Isola, J.-Y. Zhu, T. Zhou, and A. A. Efros. Image-to-image translation with conditional adversarial networks. *arxiv*, 2016. 1

[2] Z. Yan, H. Zhang, B. Wang, S. Paris, and Y. Yu. Automatic photo adjustment using deep neural networks. *ACM Trans. Graph.*, 35(2):11:1–11:15, Feb. 2016. 1