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Supplementary material on

Fully-Automatic Reflection Removal for 360-Degree Images

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Jonghyuk Park, Hyeona Kim, Eunpil Park, and Jae-Young Sim*

Ulsan National Institute of Science and Technology, Ulsan, Republic of Korea

`{jonghyukpark,gusdk304,cosmos,jysim}@unist.ac.kr`

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1. Architecture Details

Figure S-1 shows the detailed architecture of the proposed network composed of the four encoding stages, one bottleneck stage and four decoding stages. From stage 1 to stage 9, the numbers of the transformer blocks and the attention heads in each block are $(1, 2, 8, 8, 2, 8, 8, 2, 1)$, and $(1, 2, 4, 8, 16, 16, 8, 4, 2)$, respectively.

2. More Results of the Proposed Method

Figures S-2~S-21 show more qualitative results of reflection removal obtained by the proposed method. We tested 60 real 360-degree images with reflection artifacts captured in various scenarios including the test images from [1]. We visualize the residual map between the input and output images, as well as the attention maps highlighting the mixed region $\mathcal{M}$ and the reference region $\mathcal{R}$. We see that the proposed method detects the mixed and reference regions well, and removes the reflection artifacts in $\mathcal{M}$ faithfully, as shown in Figures S-2~S-19. However, in some challenging cases (Figures S-20, S-21), the performance of reflection removal is somewhat degraded.

Table S-1 shows a comparison with state-of-the-art methods in terms of network complexities and parameters. While the proposed method has ~20% GMACs of ERR-Net [3] and ~74% parameters of ABS [4], we provide much better performance as shown in Sec. 4.2 in main paper.

Metric	Methods				
	ERRNet [3]	IBCLN [2]	ABS [4]	ZS360 [1]	Ours
GMACs	836.92G	130.92G	117.55G	159.27G	171.75G
# Params	18.58M	6.08M	68.45M	0.60M	51.12M

Table S-1. Comparison of network complexities and parameters

References

[1] Byeong-Ju Han and Jae-Young Sim. Zero-shot learning for reflection removal of single 360-degree image. In *ECCV*, pages 533–548. Springer, 2022.

[2] Chao Li, Yixiao Yang, Kun He, Stephen Lin, and John E Hopcroft. Single image reflection removal through cascaded refinement. In *CVPR*, pages 3565–3574, 2020.

[3] Kaixuan Wei, Jiaolong Yang, Ying Fu, David Wipf, and Hua Huang. Single image reflection removal exploiting misaligned training data and network enhancements. In *CVPR*, pages 8178–8187, 2019.

[4] Qian Zheng, Boxin Shi, Jinnan Chen, Xudong Jiang, Ling-Yu Duan, and Alex C Kot. Single image reflection removal with absorption effect. In *CVPR*, pages 13395–13404, 2021.
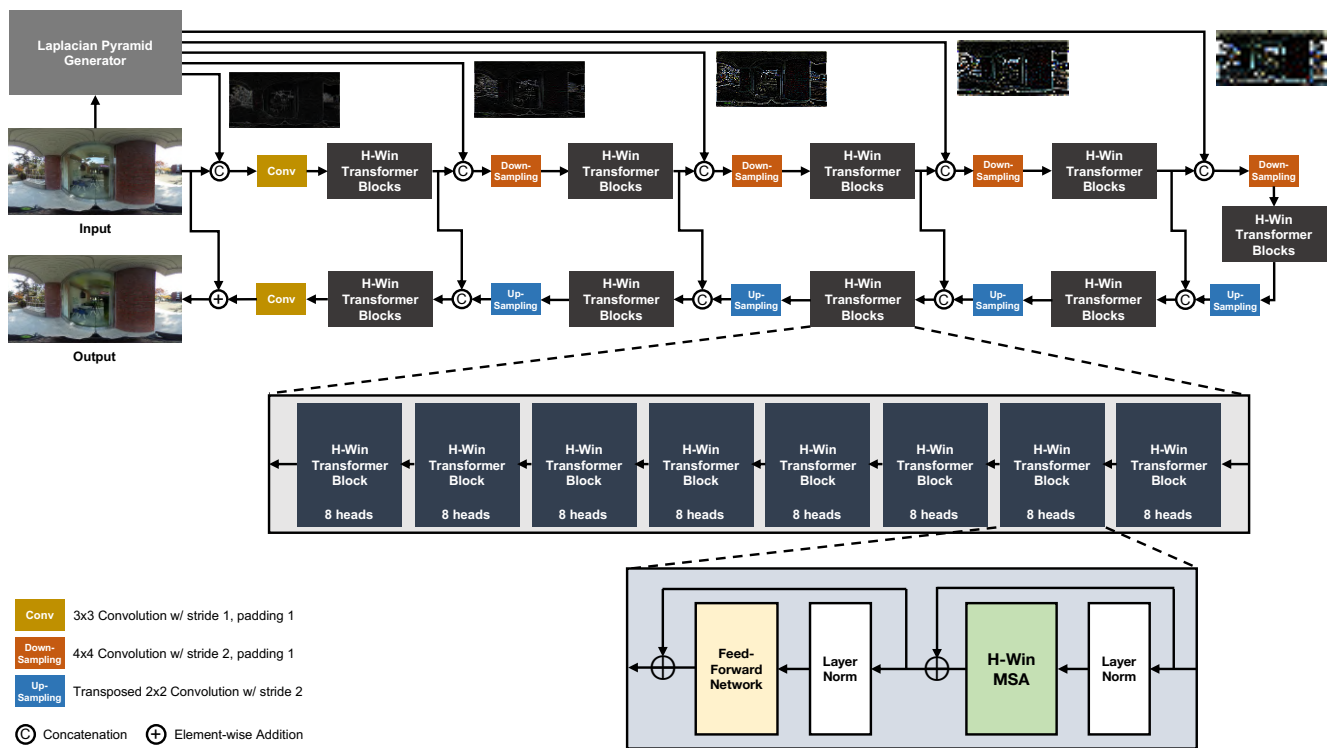
Figure S-1. Detailed architecture of the proposed network.

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |
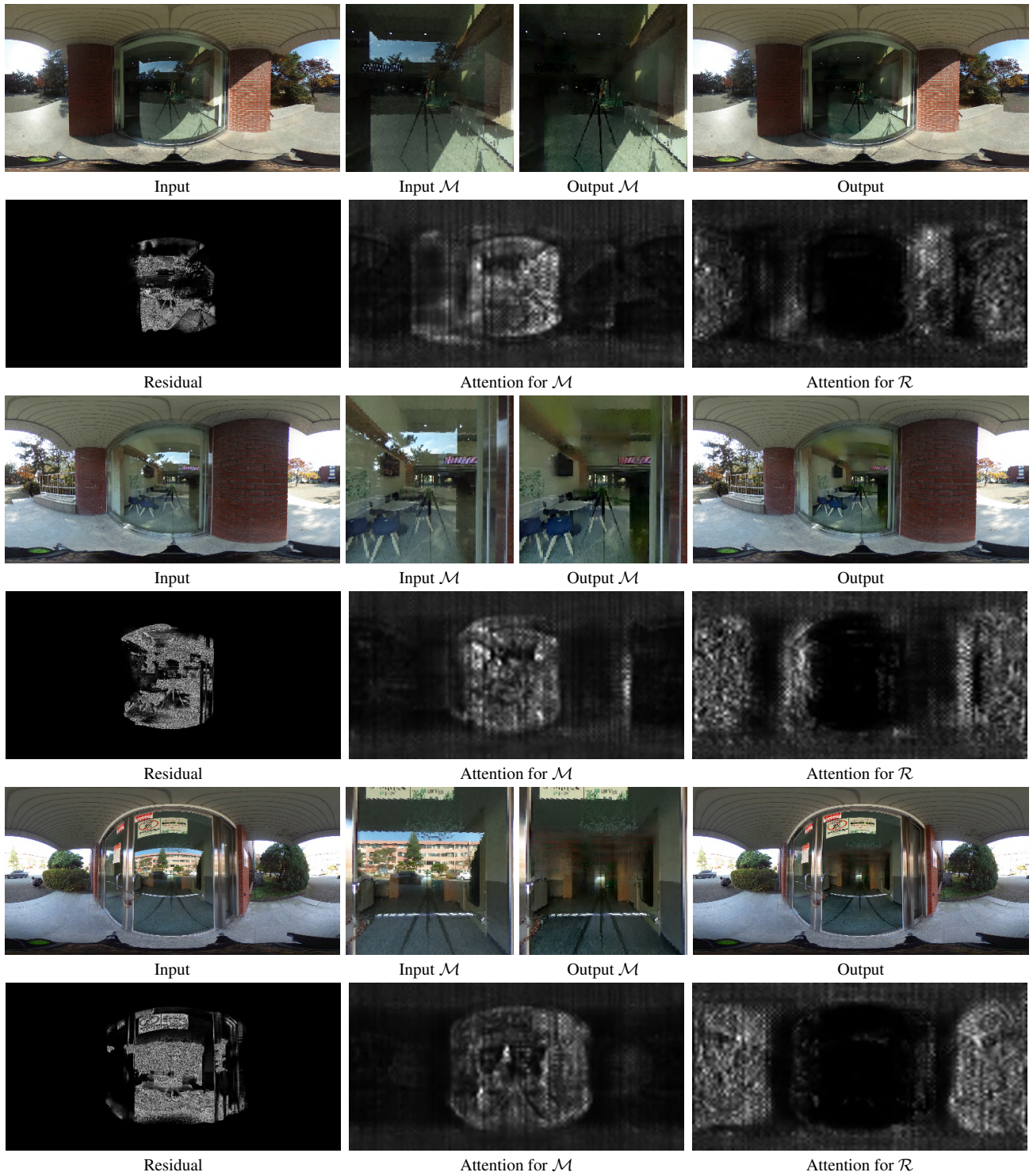
Figure S-2. Qualitative results of the proposed method.

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output

Residual	Attention for $\mathcal{M}$	Attention for $\mathcal{R}$

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output

Residual	Attention for $\mathcal{M}$	Attention for $\mathcal{R}$

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output

Residual	Attention for $\mathcal{M}$	Attention for $\mathcal{R}$
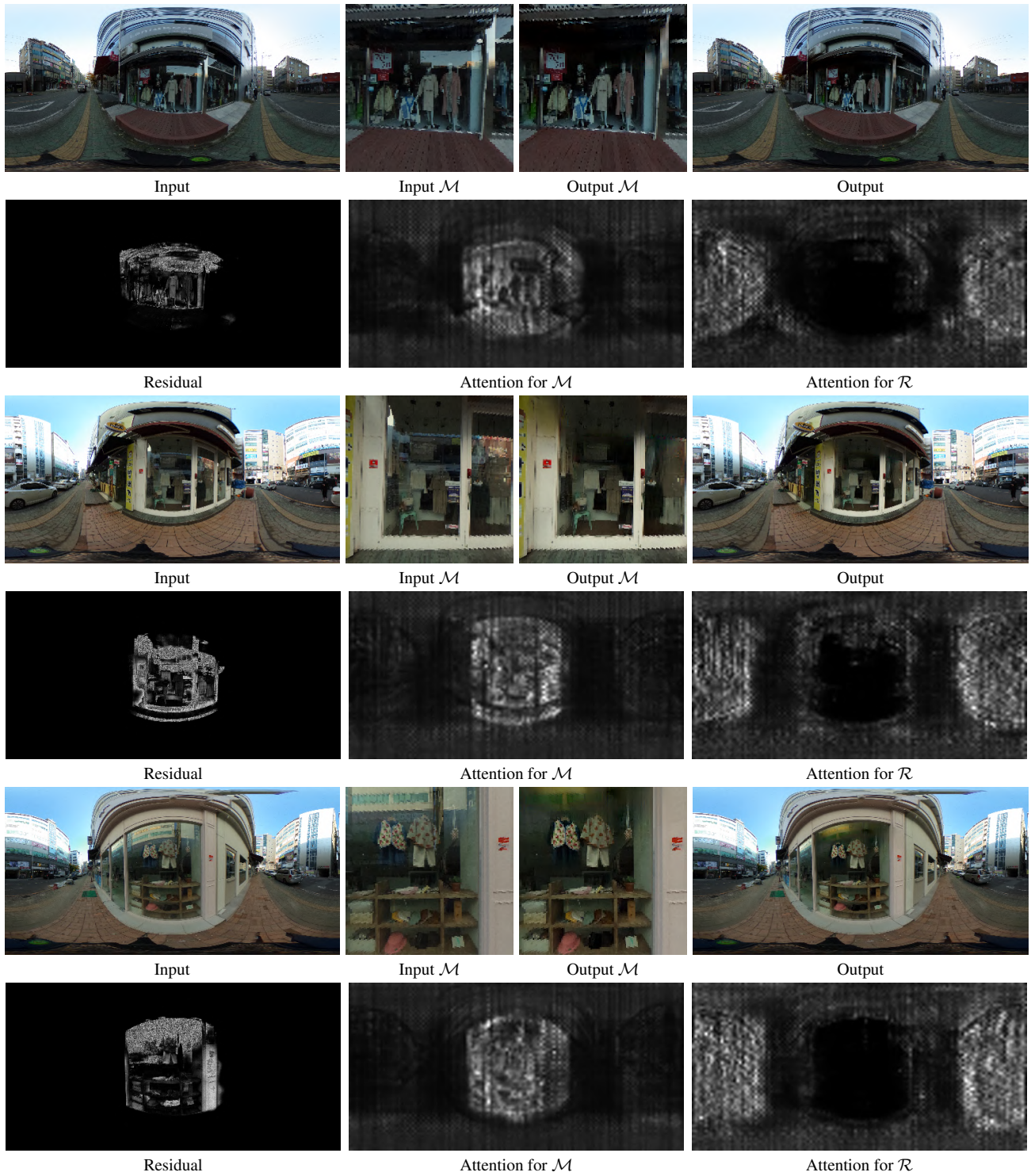
Figure S-3. Qualitative results of the proposed method.
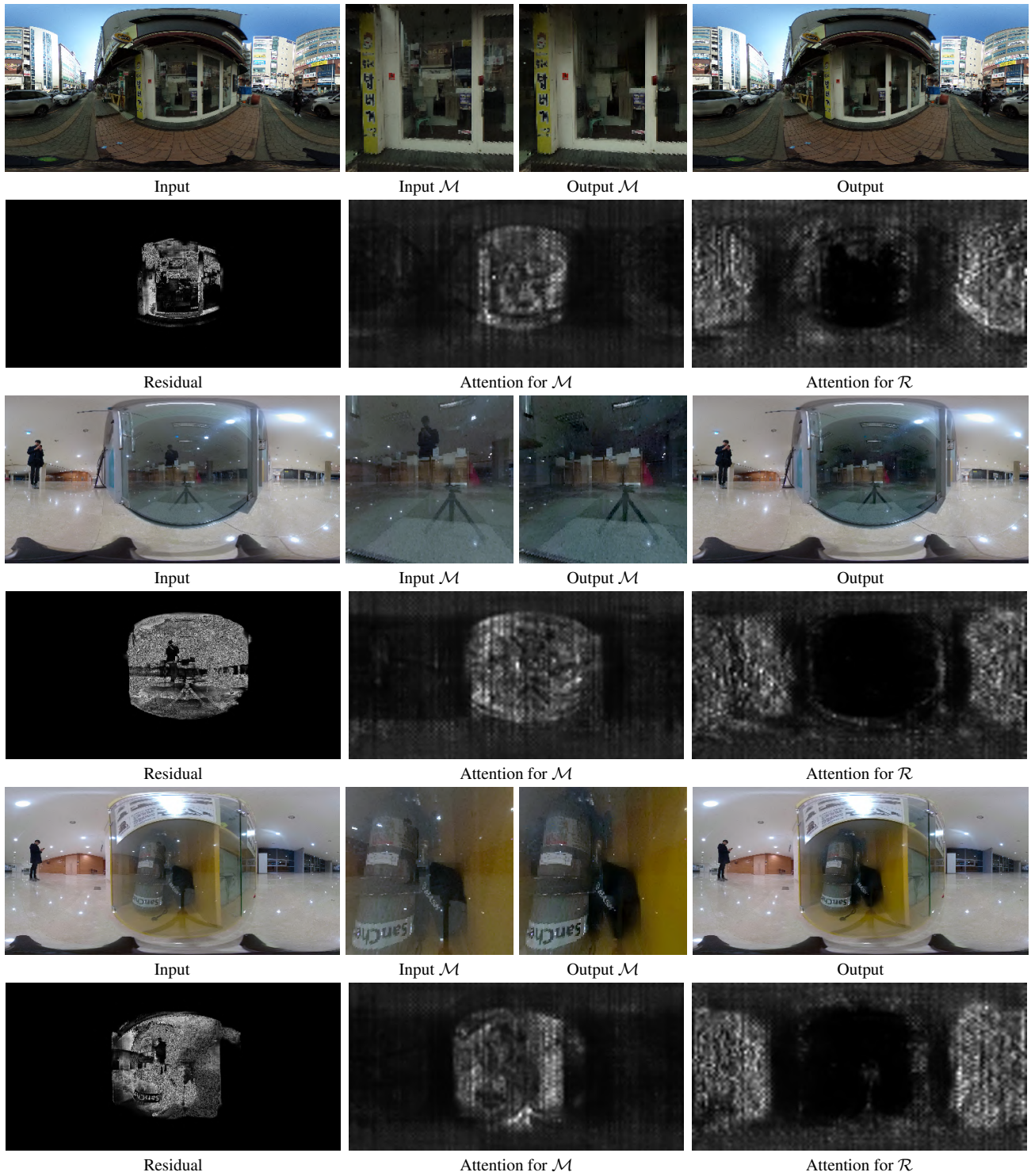
Figure S-4. Qualitative results of the proposed method.

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output

Residual	Attention for $\mathcal{M}$	Attention for $\mathcal{R}$

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output

Residual	Attention for $\mathcal{M}$	Attention for $\mathcal{R}$

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output

Residual	Attention for $\mathcal{M}$	Attention for $\mathcal{R}$
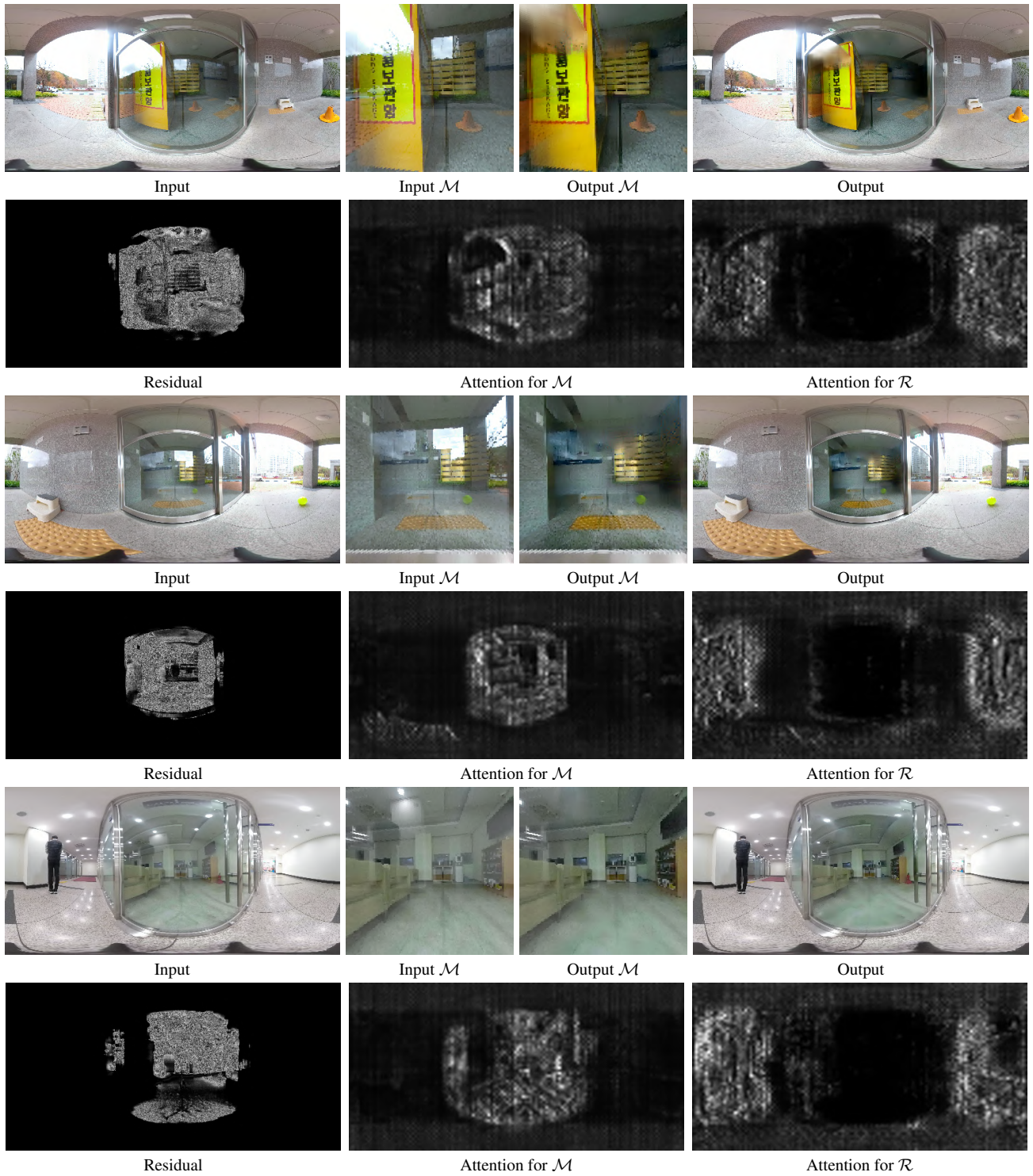
Figure S-5. Qualitative results of the proposed method.

Input Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual Attention for $\mathcal{M}$ Attention for $\mathcal{R}$
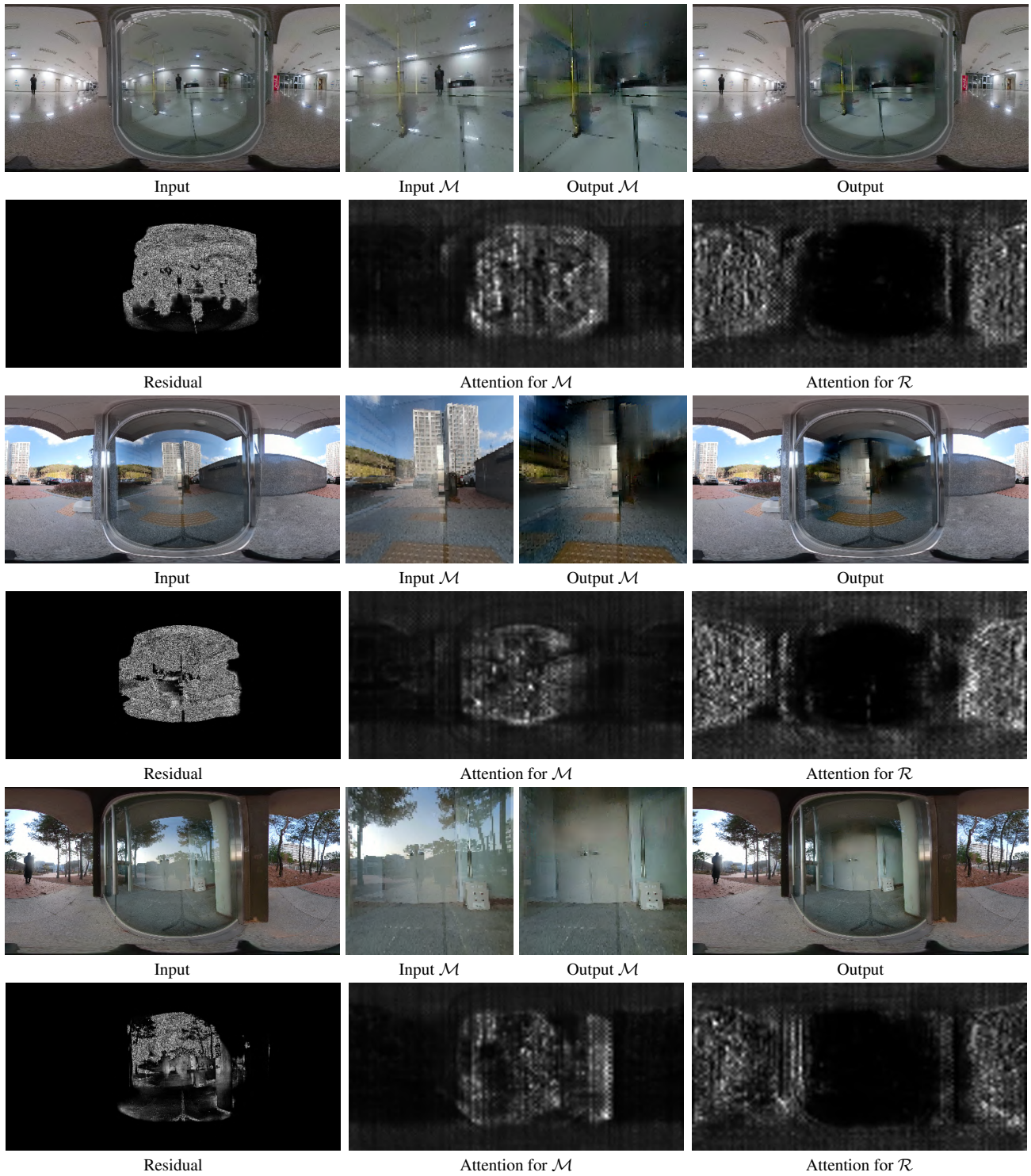
Figure S-6. Qualitative results of the proposed method.

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

Figure S-7. Qualitative results of the proposed method.

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output
Residual	Attention for $\mathcal{M}$		Attention for $\mathcal{R}$
Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output
Residual	Attention for $\mathcal{M}$		Attention for $\mathcal{R}$
Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output
Residual	Attention for $\mathcal{M}$		Attention for $\mathcal{R}$

Figure S-8. Qualitative results of the proposed method.

Input　　　　　　　　　Input $\mathcal{M}$　　　　　　　　Output $\mathcal{M}$　　　　　　　　Output

Residual　　　　　　　Attention for $\mathcal{M}$　　　　　　Attention for $\mathcal{R}$

Input　　　　　　　　　Input $\mathcal{M}$　　　　　　　　Output $\mathcal{M}$　　　　　　　　Output

Residual　　　　　　　Attention for $\mathcal{M}$　　　　　　Attention for $\mathcal{R}$

Input　　　　　　　　　Input $\mathcal{M}$　　　　　　　　Output $\mathcal{M}$　　　　　　　　Output

Residual　　　　　　　Attention for $\mathcal{M}$　　　　　　Attention for $\mathcal{R}$
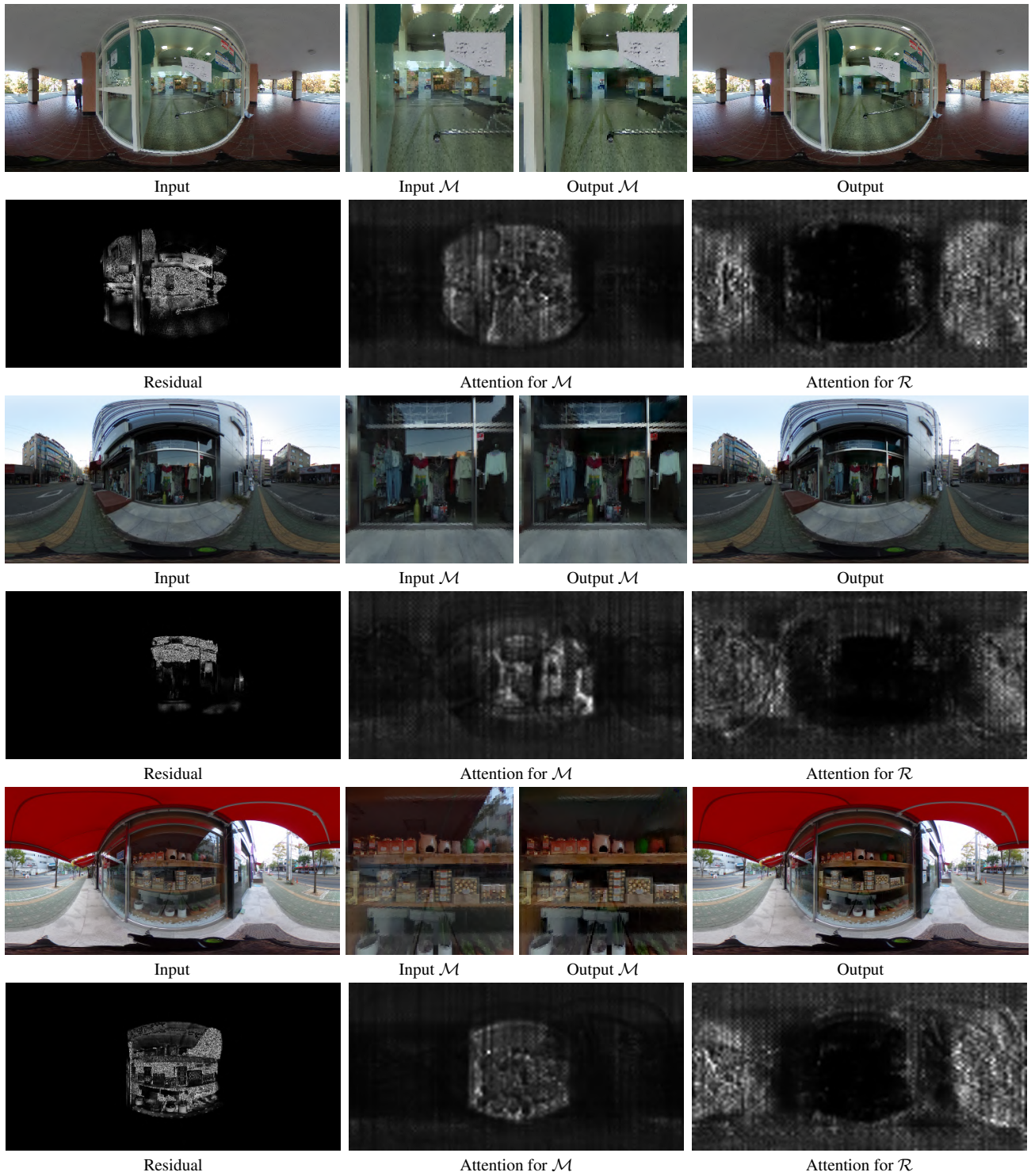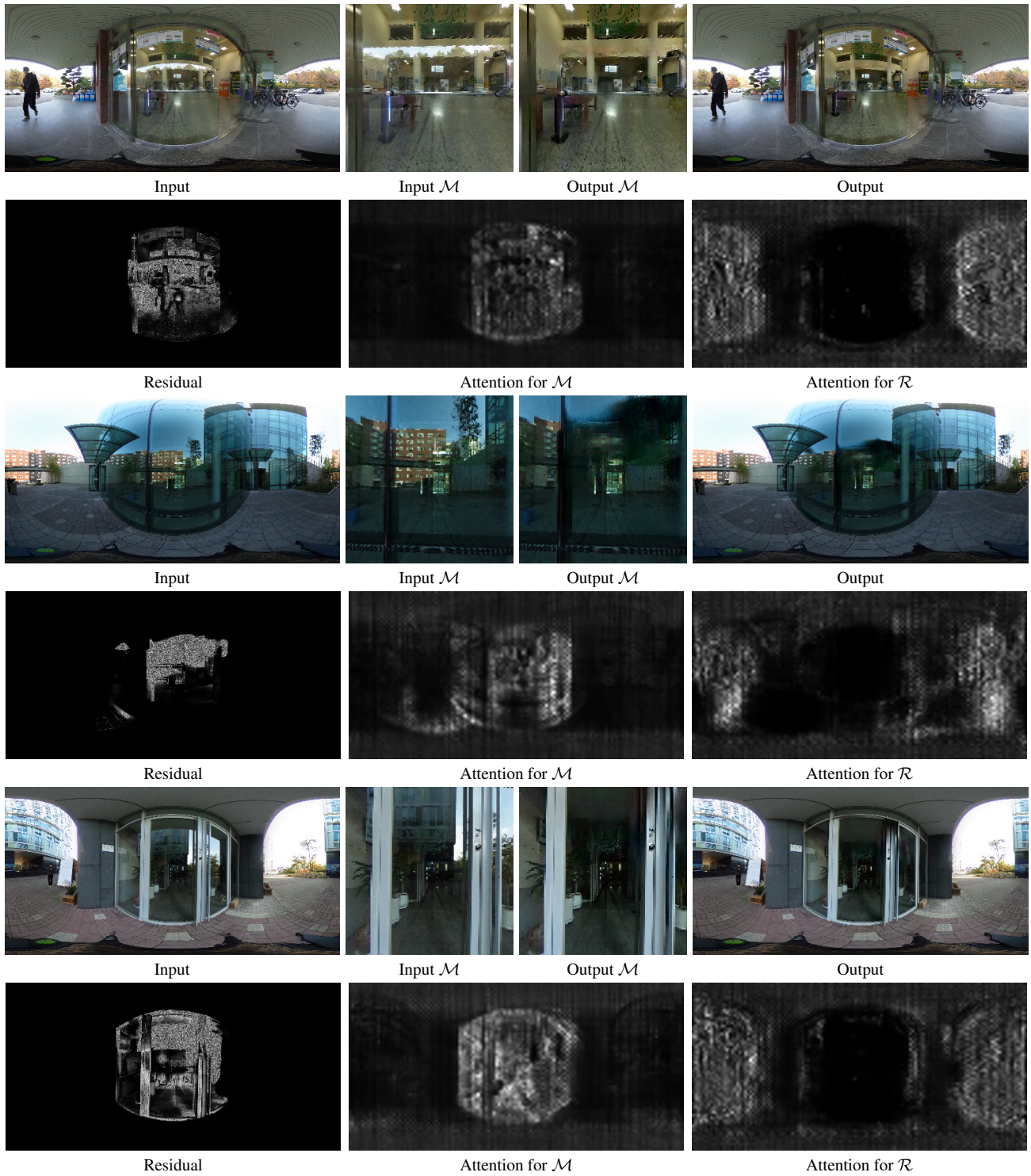
Figure S-9. Qualitative results of the proposed method.

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$
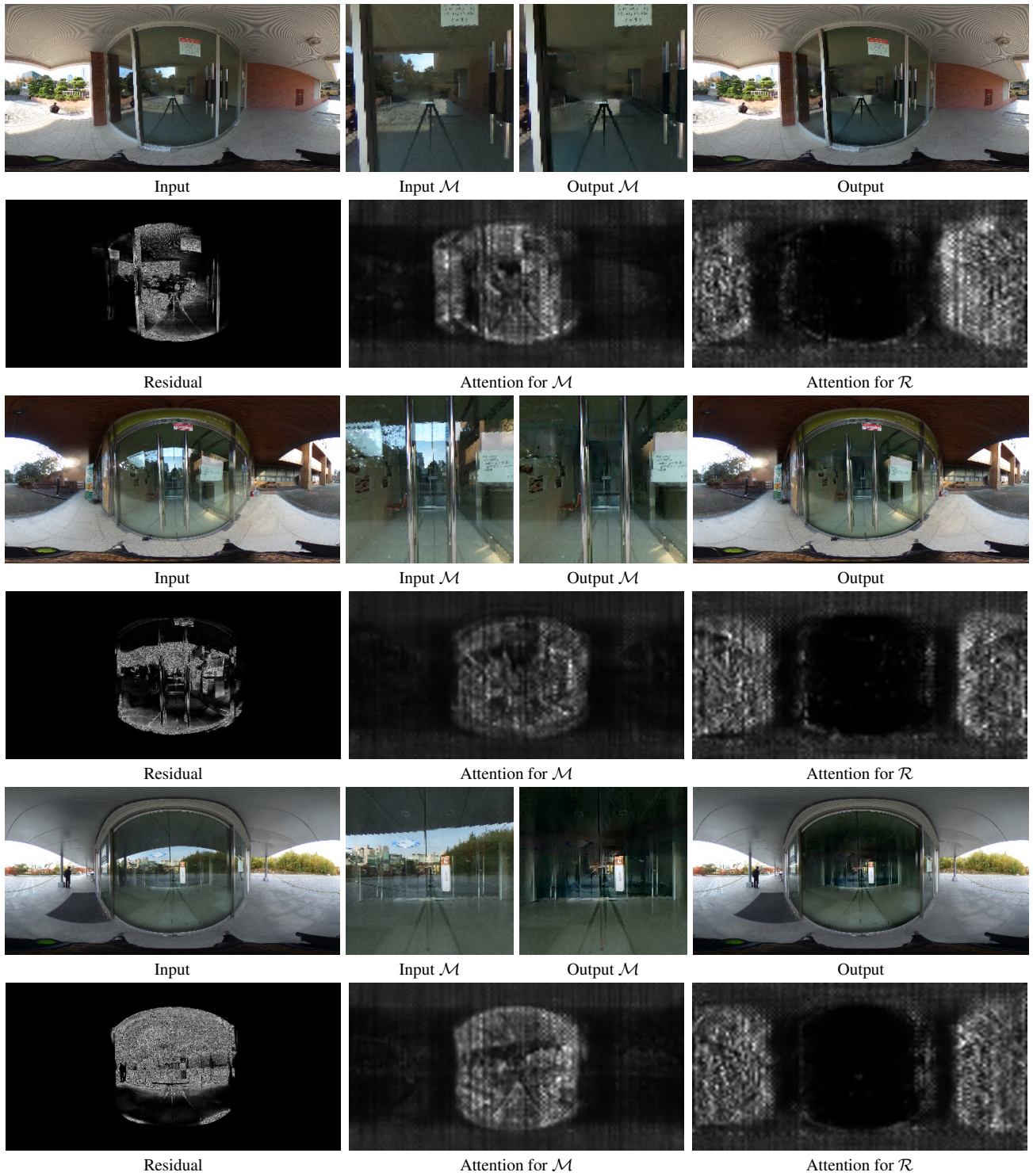
Figure S-10. Qualitative results of the proposed method.

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output

Residual	Attention for $\mathcal{M}$	Attention for $\mathcal{R}$

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output

Residual	Attention for $\mathcal{M}$	Attention for $\mathcal{R}$

Input	Input $\mathcal{M}$	Output $\mathcal{M}$	Output

Residual	Attention for $\mathcal{M}$	Attention for $\mathcal{R}$
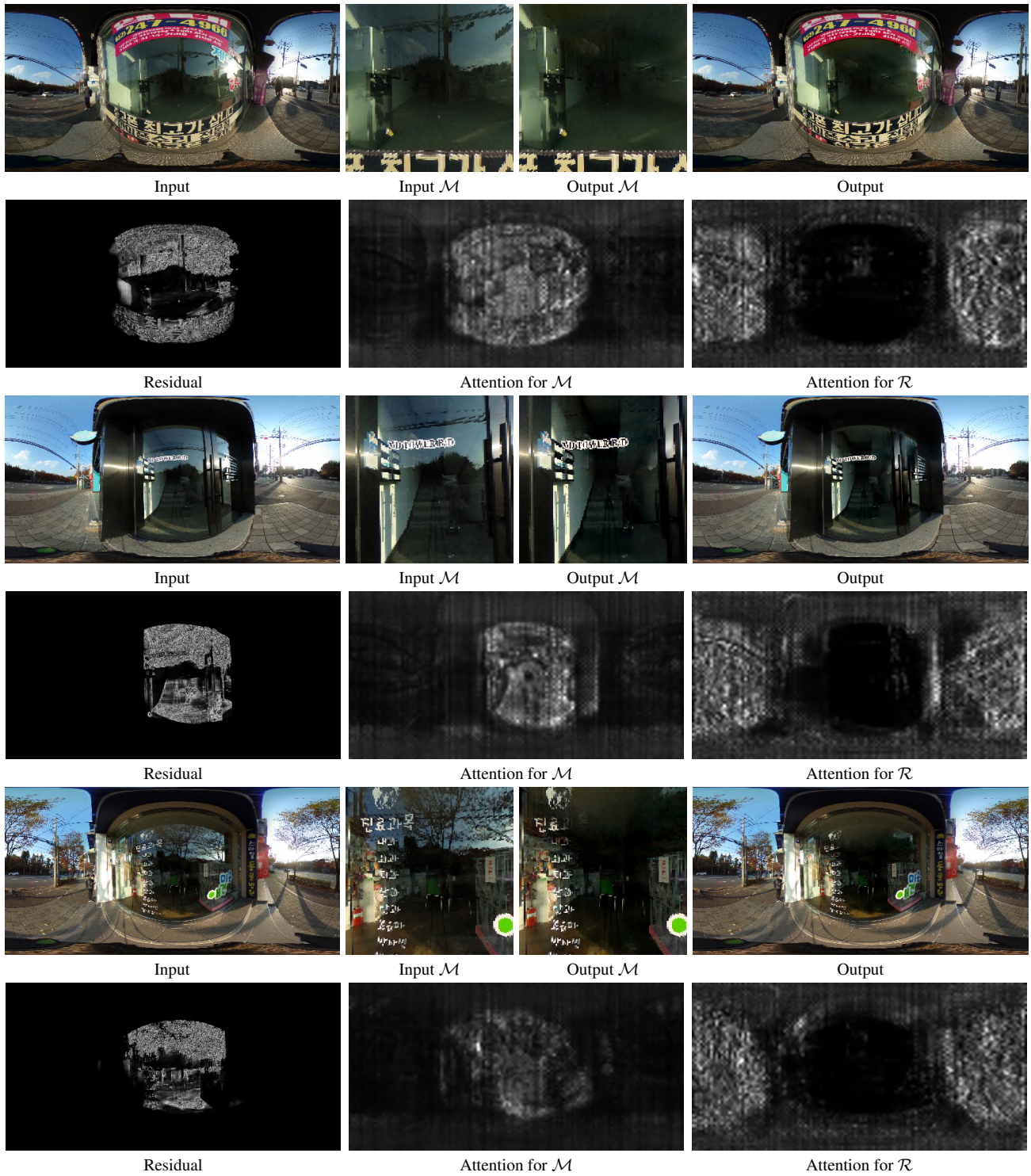
Figure S-11. Qualitative results of the proposed method.

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$
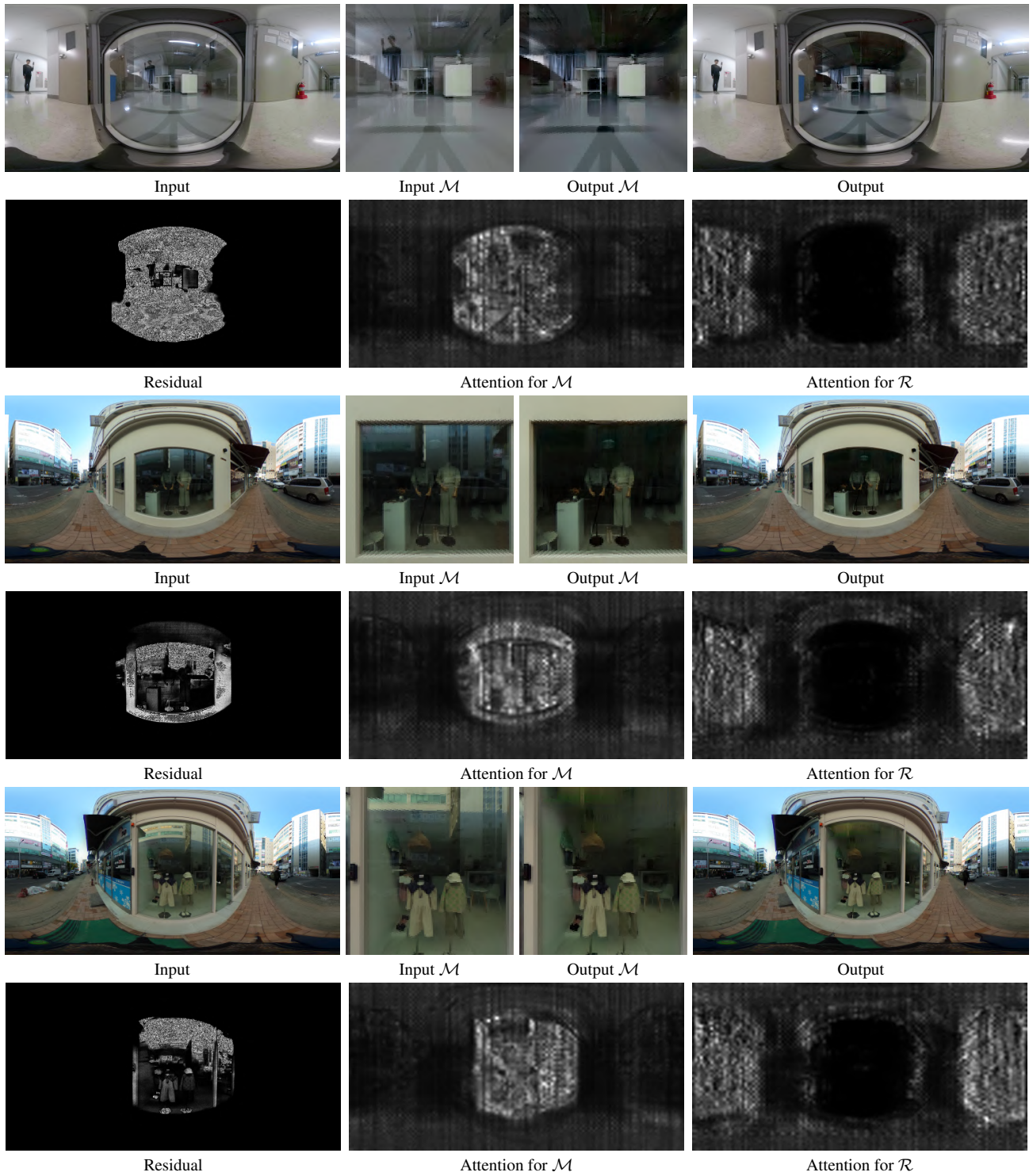
Figure S-12. Qualitative results of the proposed method.

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |
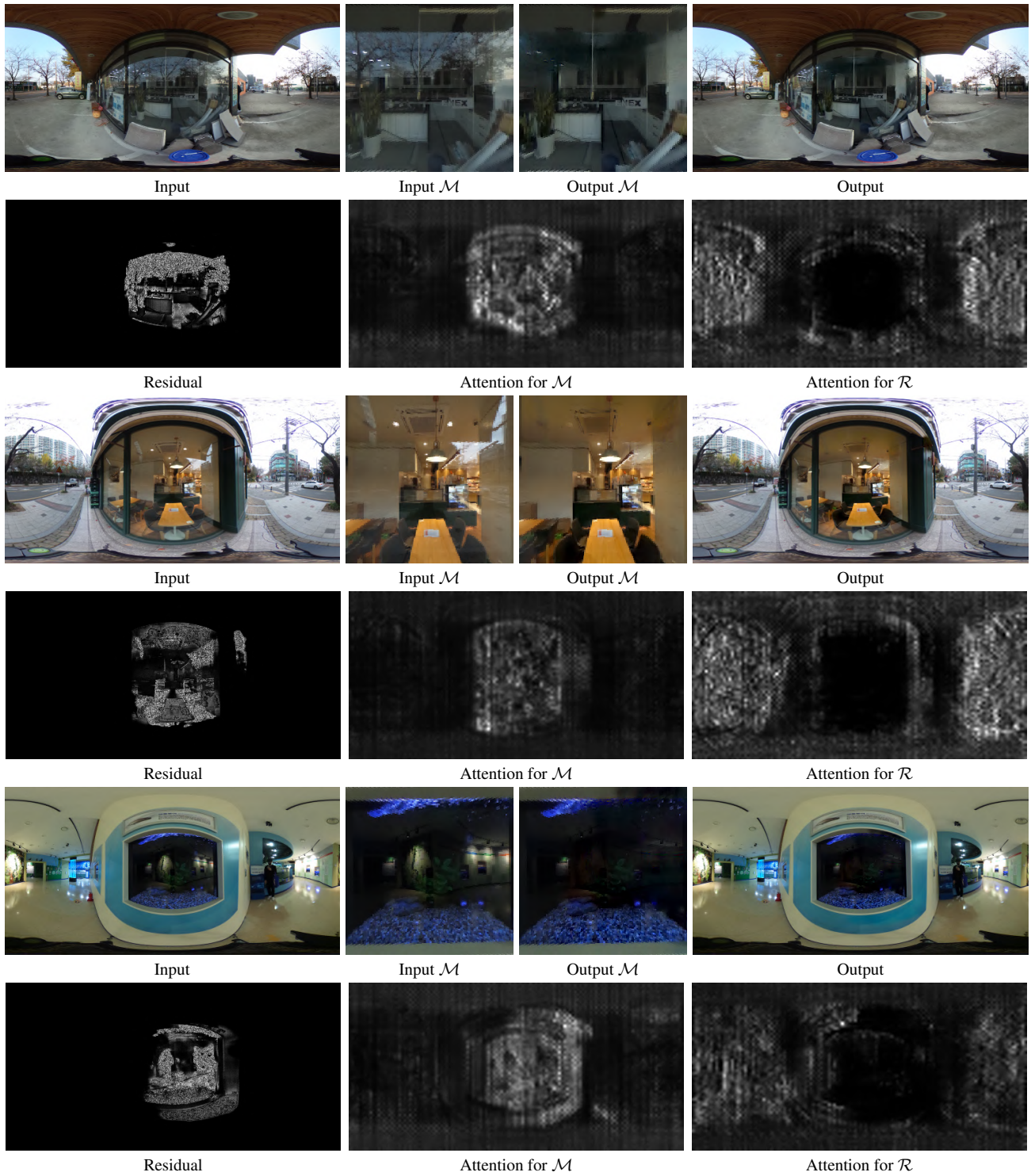
Figure S-13. Qualitative results of the proposed method.

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |
| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |
| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |
| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |
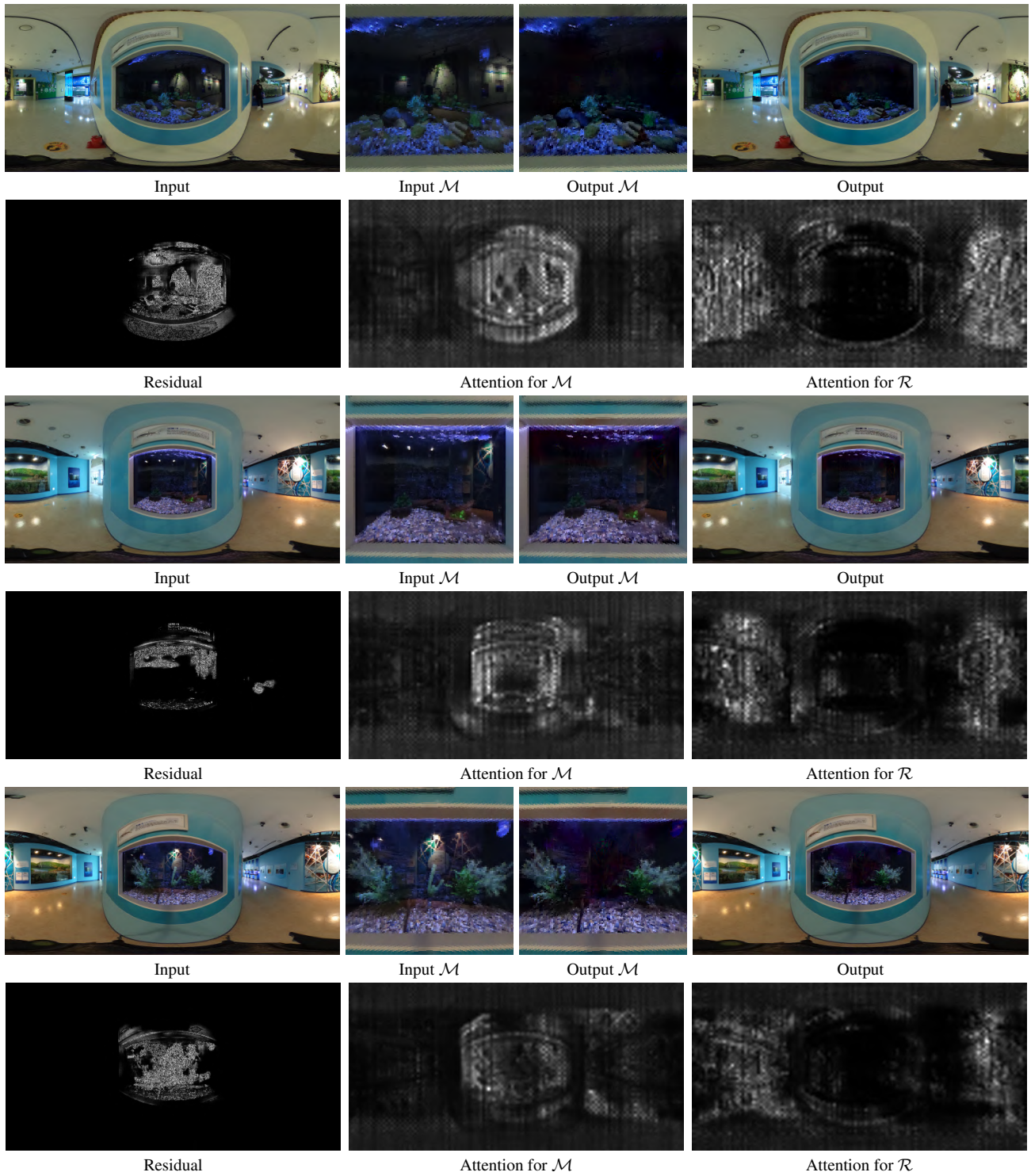
Figure S-14. Qualitative results of the proposed method.

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Figure S-15. Qualitative results of the proposed method.

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |
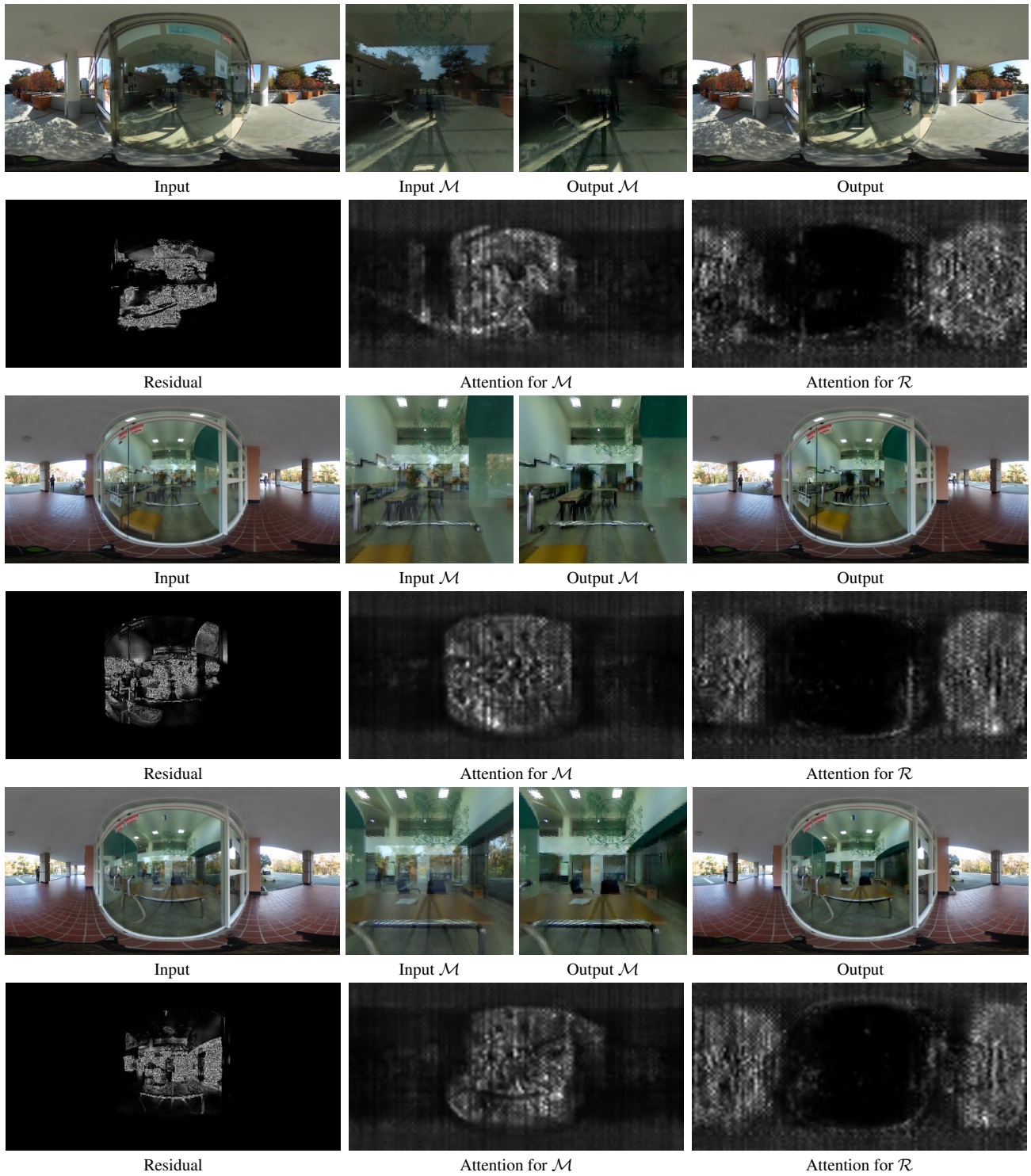
Figure S-16. Qualitative results of the proposed method.

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output
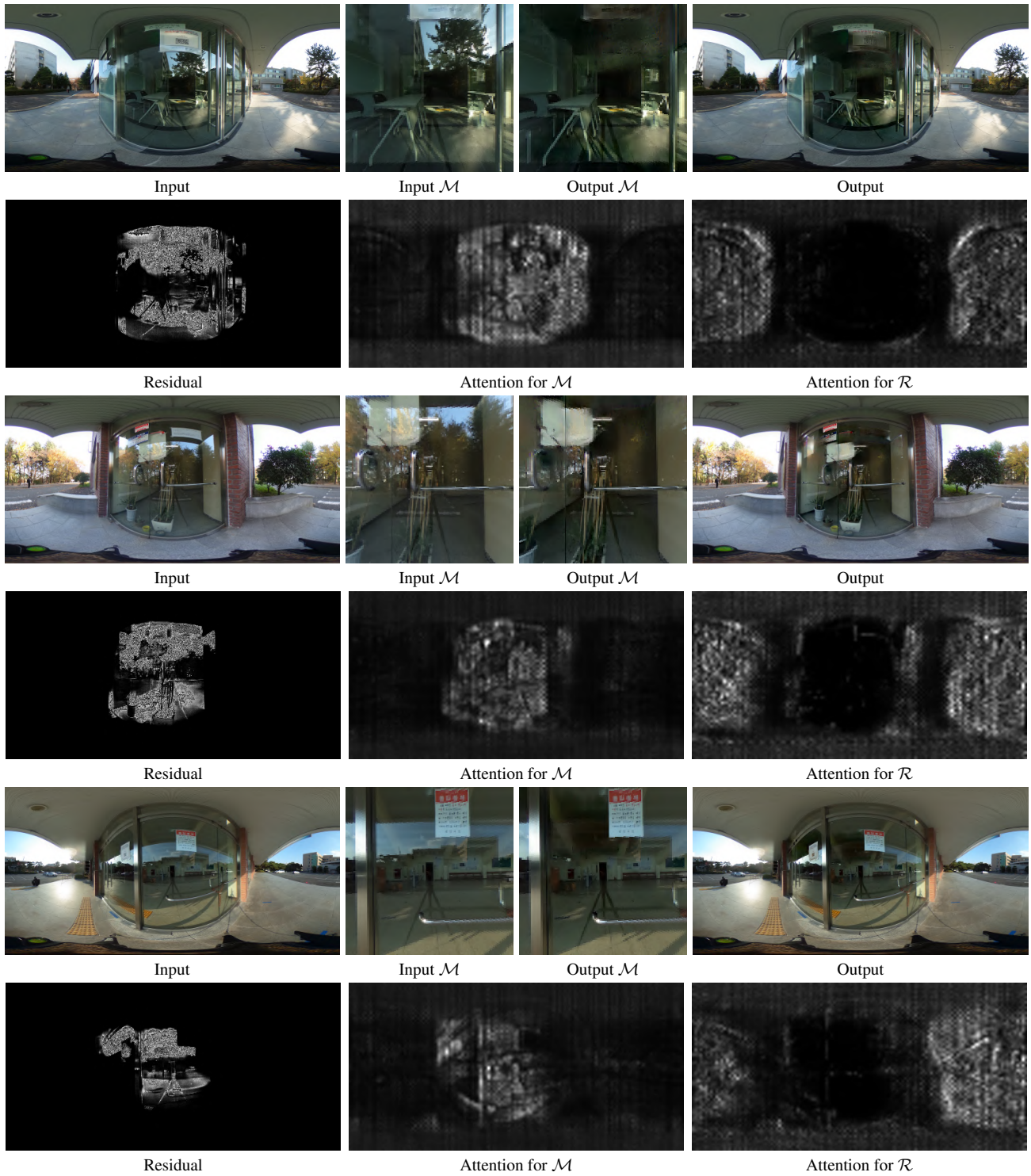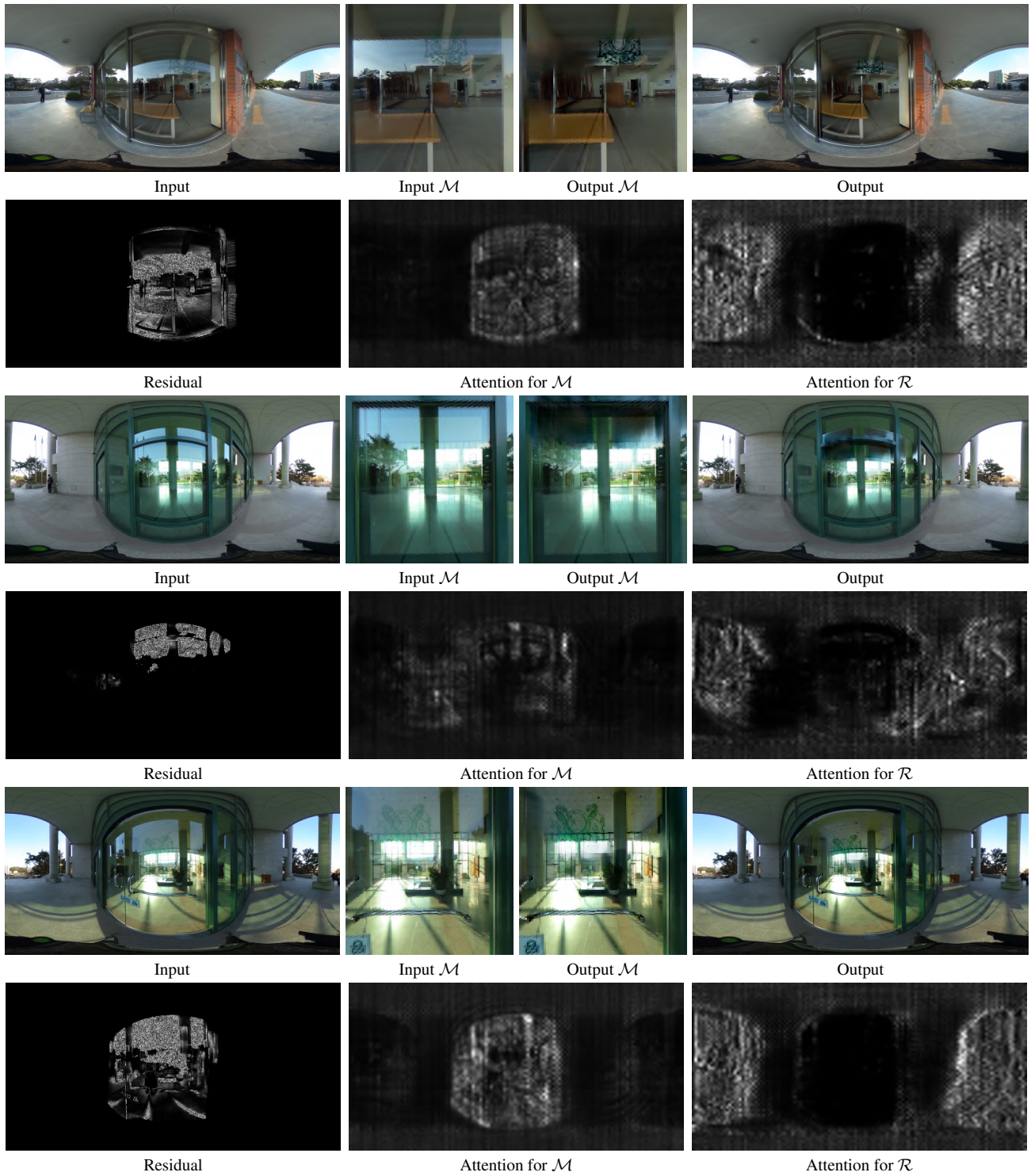
Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Figure S-17. Qualitative results of the proposed method.

Figure S-18. Qualitative results of the proposed method.

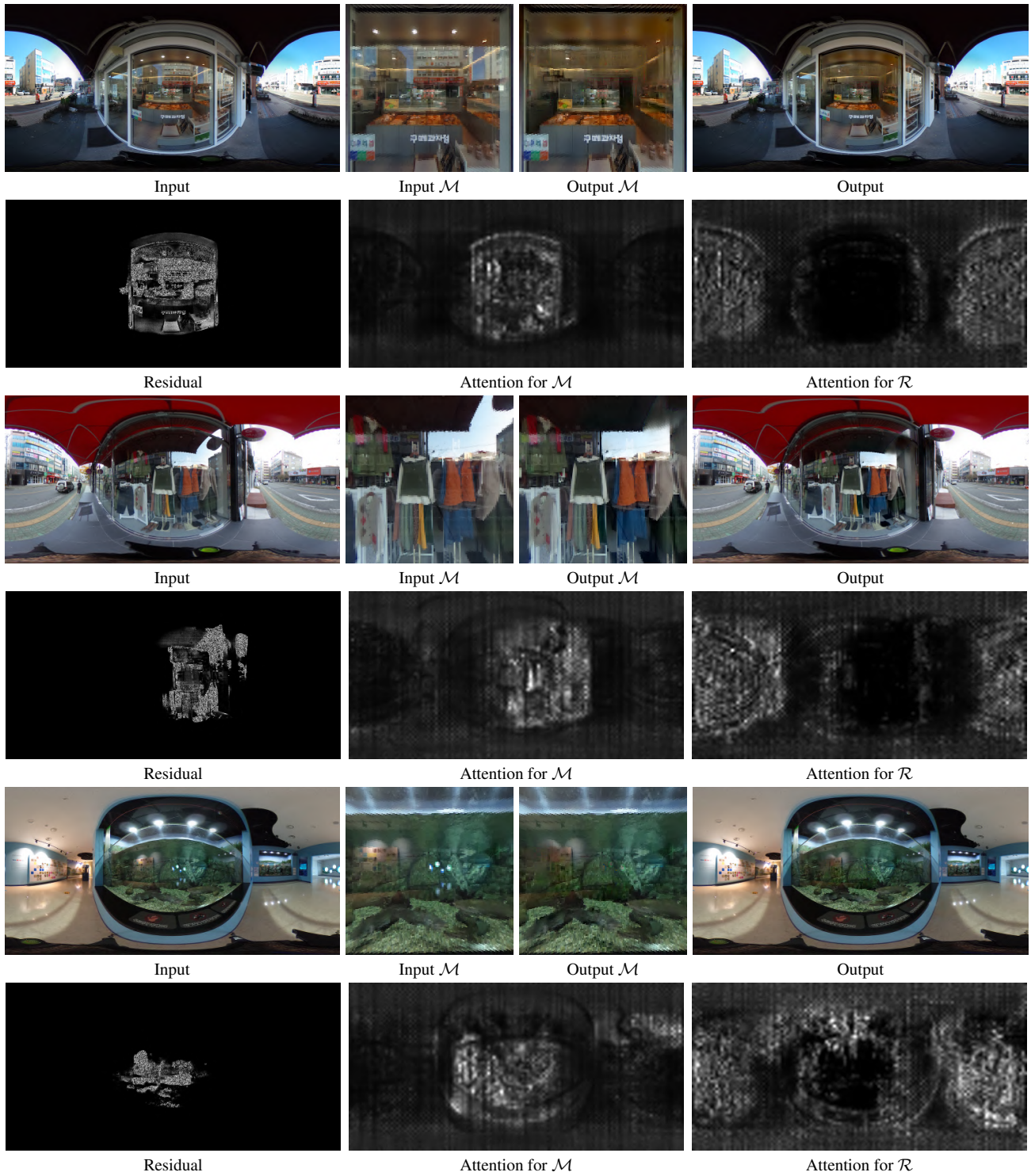| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

| Input | Input $\mathcal{M}$ | Output $\mathcal{M}$ | Output |

| Residual | Attention for $\mathcal{M}$ | Attention for $\mathcal{R}$ |

Figure S-19. Qualitative results of the proposed method.

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$

Input   Input $\mathcal{M}$ Output $\mathcal{M}$ Output

Residual   Attention for $\mathcal{M}$ Attention for $\mathcal{R}$
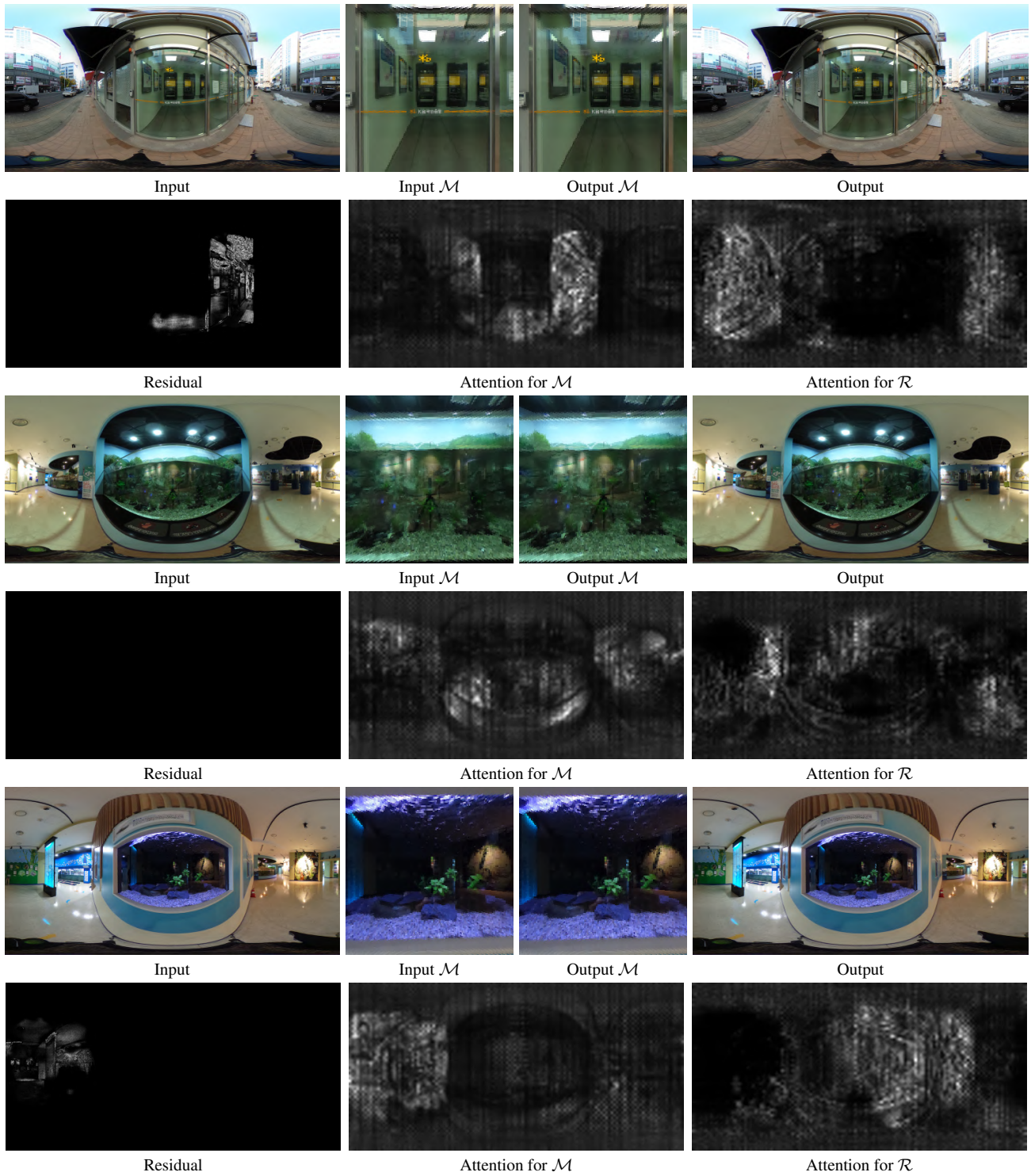
Figure S-20. Qualitative results of the proposed method.

Input　　　　　　　Input $\mathcal{M}$　　　　　　Output $\mathcal{M}$　　　　　　Output

Residual　　　　　　Attention for $\mathcal{M}$　　　　　　Attention for $\mathcal{R}$

Input　　　　　　　Input $\mathcal{M}$　　　　　　Output $\mathcal{M}$　　　　　　Output

Residual　　　　　　Attention for $\mathcal{M}$　　　　　　Attention for $\mathcal{R}$

Input　　　　　　　Input $\mathcal{M}$　　　　　　Output $\mathcal{M}$　　　　　　Output

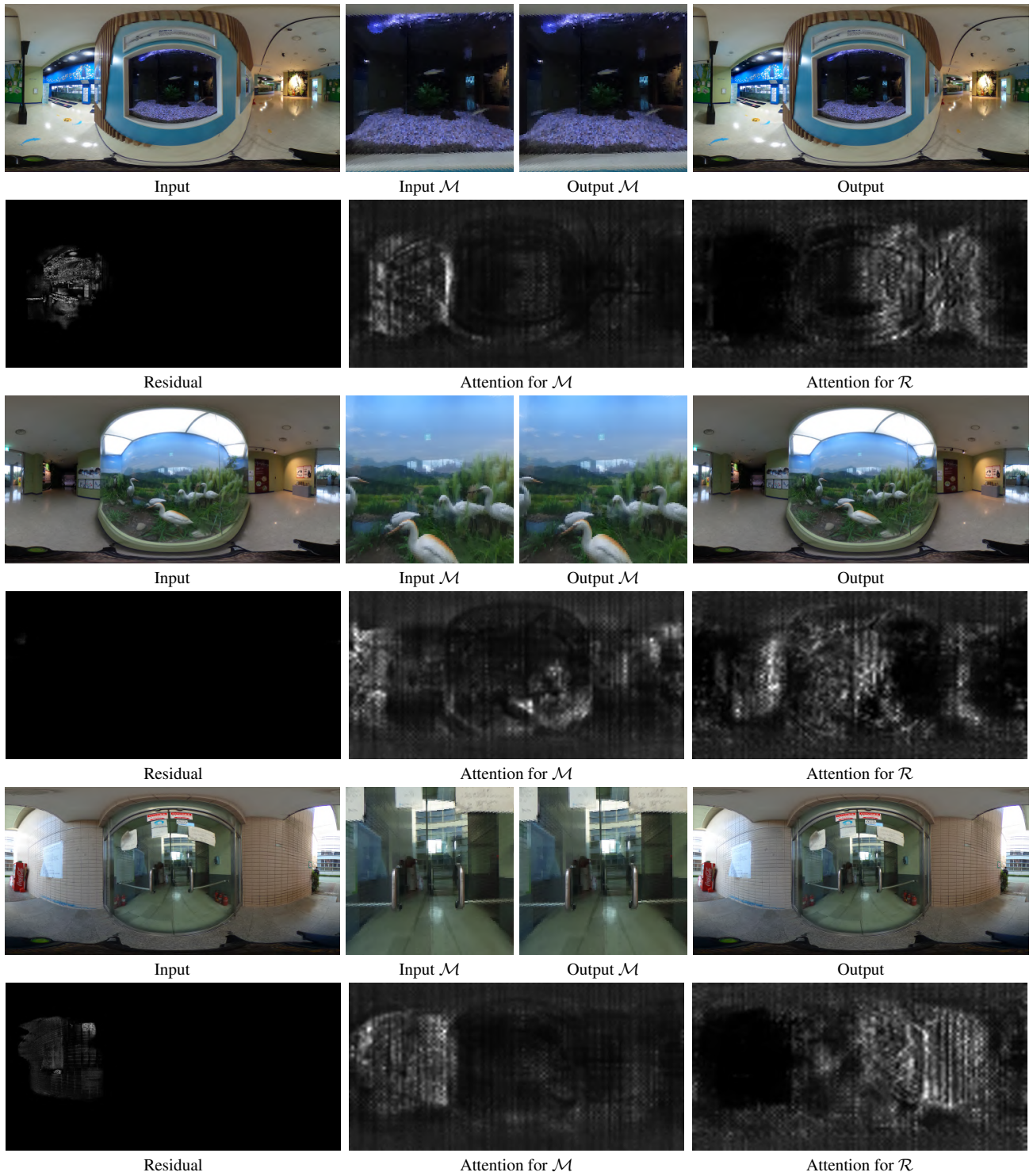Residual　　　　　　Attention for $\mathcal{M}$　　　　　　Attention for $\mathcal{R}$

Figure S-21. Qualitative results of the proposed method.