Supplementary Material: End-to-End Complex Lens Design with Differentiable Ray Tracing

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CCS Concepts: • **Computing methodologies → Ray tracing**; **Computational photography**.

Additional Key Words and Phrases: Complex lens, Differentiable, Raytracing, End-to-end

ACM Reference Format:
Qilin Sun, Congli Wang, Qiang Fu, Xiong Dun, and Wolfgang Heidrich. 2021. Supplementary Material: End-to-End Complex Lens Design with Differentiable Ray Tracing. *ACM Trans. Graph.* 40, 4, Article 1 (August 2021), 11 pages. https://doi.org/10.1145/3450626.3459674

1 INITIAL LENS DESIGN AND OPTIMIZED PARAMETERS

For our applications, we adopt two initial lens designs for those applications. The details of the initial lens design and our final lens design are shown in Table 1 and Table 2. Figure 1 shows the PSF performance of our optimized lens design, the initial lens design, the design of learned large field-of-view imaging [Peng et al. 2019], reference pinhole camera, AL2550-A, and ACA254-050-A. Our PSF performance at a large FOV has a stronger peak compared with the initial lens design. which means it can preserve the high-frequency information but left some haze low-frequency aberrations. This is a compromise to preserving more details. Figure 2 shows the PSF performance of our lens design, the initial lens design, AL2550-A and ACA254-050-A. Obviously, ours has a better performance at the LFOV.

Cooke triplet. We made the comparison for the application of LFOV imaging with the Cooke triplet. The parameters are the same as the three-lens design's initial parameters shown in Table 1.

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0730-0301/2021/8-ART1 $15.00
https://doi.org/10.1145/3450626.3459674

2 HIGH QUALITY EXPERIMENTAL RESULTS

We show the zoomed results in Figure 3, Figure 4, Figure 5 and Figure 6 for the application LFOV with a compact and low cost two lenses design.

We show the zoomed results in Figure 7, Figure 8 and Figure 9 for the application EDOF with a compact and low cost three lenses design. We also release some references take by a Sony $28-70mm$ zoom lens at $50mm/F4.5$.

REFERENCES

Yifan Peng, Qilin Sun, Xiong Dun, Gordon Wetzstein, Wolfgang Heidrich, and Felix Heide. 2019. Learned Large Field-of-View Imaging with Thin-Plate Optics. *ACM Transactions on Graphics (TOG)* 38, 6, Article 219 (Nov. 2019), 14 pages.

Table 1. Lens parameters of LFOV imaging and its initial design. The optimized parameters for LFOV are marked in bold font.

type	distance	roc	diameter	material	κ	$a_{j=\{4,6,8,10\}}$
O	0	0	100	AIR	-	-
S	0	14.418	13.4981	PMMA	0/**0.036**	-
S	5.33	-316.253	12.0611	AIR	0/**0.002**	-8.5e-5 -2.89e-7 -4.69e-9 7.09e-11
S	1.71	-18.907	12.0387	POLYCARB	0/**-0.138**	-
S	8	-45.607	14.0455	AIR	0/**-0.009**	1.03e-4 -1.27e-7 1.70e-8 -1.40e-10
I	40.86	0	30.9591	AIR	-	-

Table 2. Lens parameters of EDOF imaging and its initial design. The optimized parameters for LFOV are marked in bold font.

type	distance	roc	diameter	material	κ	$a_{j=\{4,6,8,10\}}$
O	0	0	100	AIR	-	-
S	0	13.086	13.78	PMMA	0/**0.38**	-
S	5.86	-31.771	13.57	AIR	0	6.5e-5 -4.06e-7 6.22e-9 -0.67e-11
S	0.72	-93.098	13.28	POLYCARB	0/**0.015**	-
S	5	17.592	12.58	AIR	0/-**1.52**	-
S	4.56	-9.823	12.86	POLYCARB	0/**-0.39**	-
S	5	-11.515	16.25	AIR	0	3.9e-5 6.81e-7 -8.73e-8 1.54e-10
I	32.561	0	30.9591	AIR	-	-

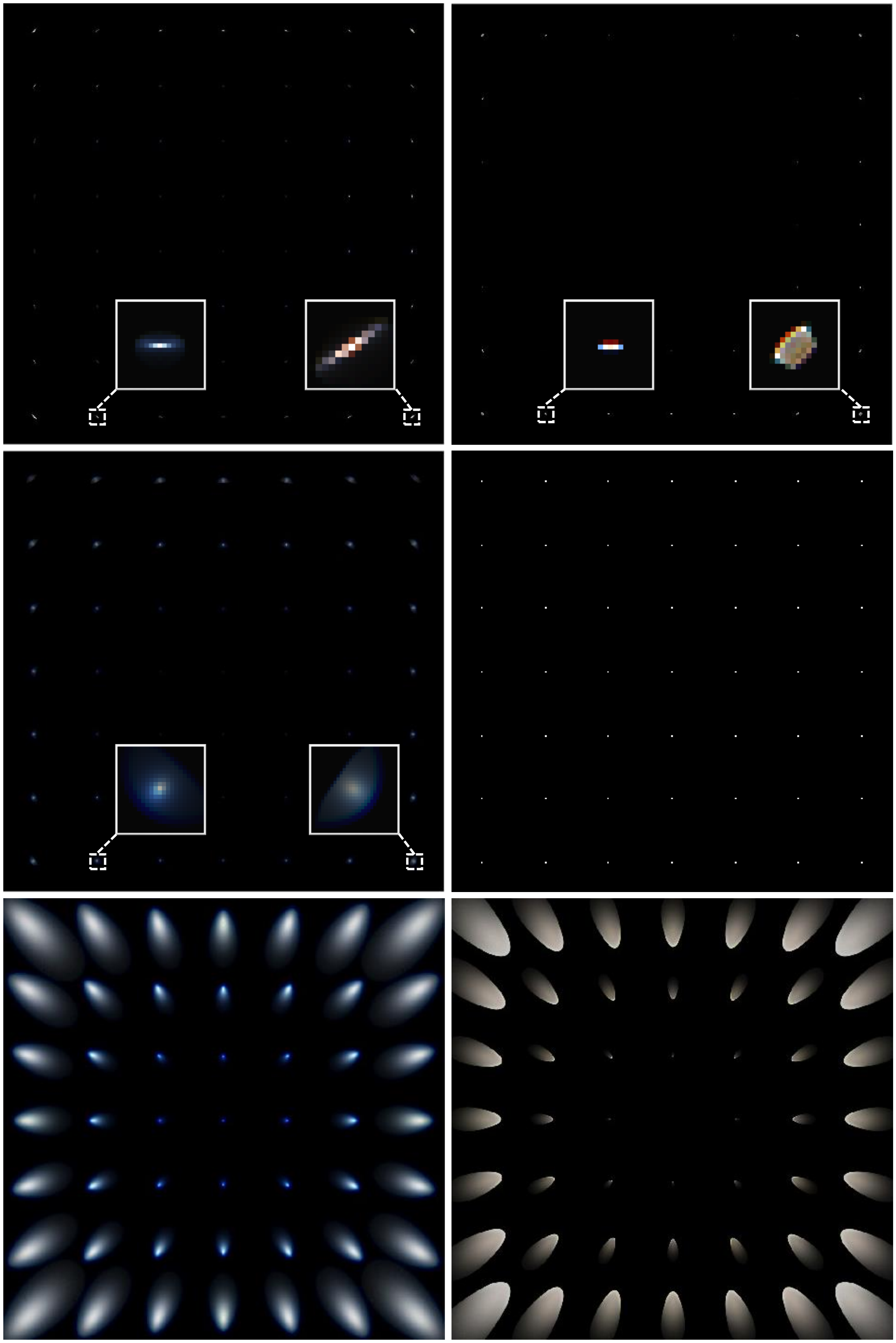

Fig. 1. FOV performace of the initial lens design (top right), our design (top left). LFOV19[Peng et al. 2019] (middle left), reference pinhole (middle right), AL2550-A (bottom left) and ACA254-050-A (bottom right).

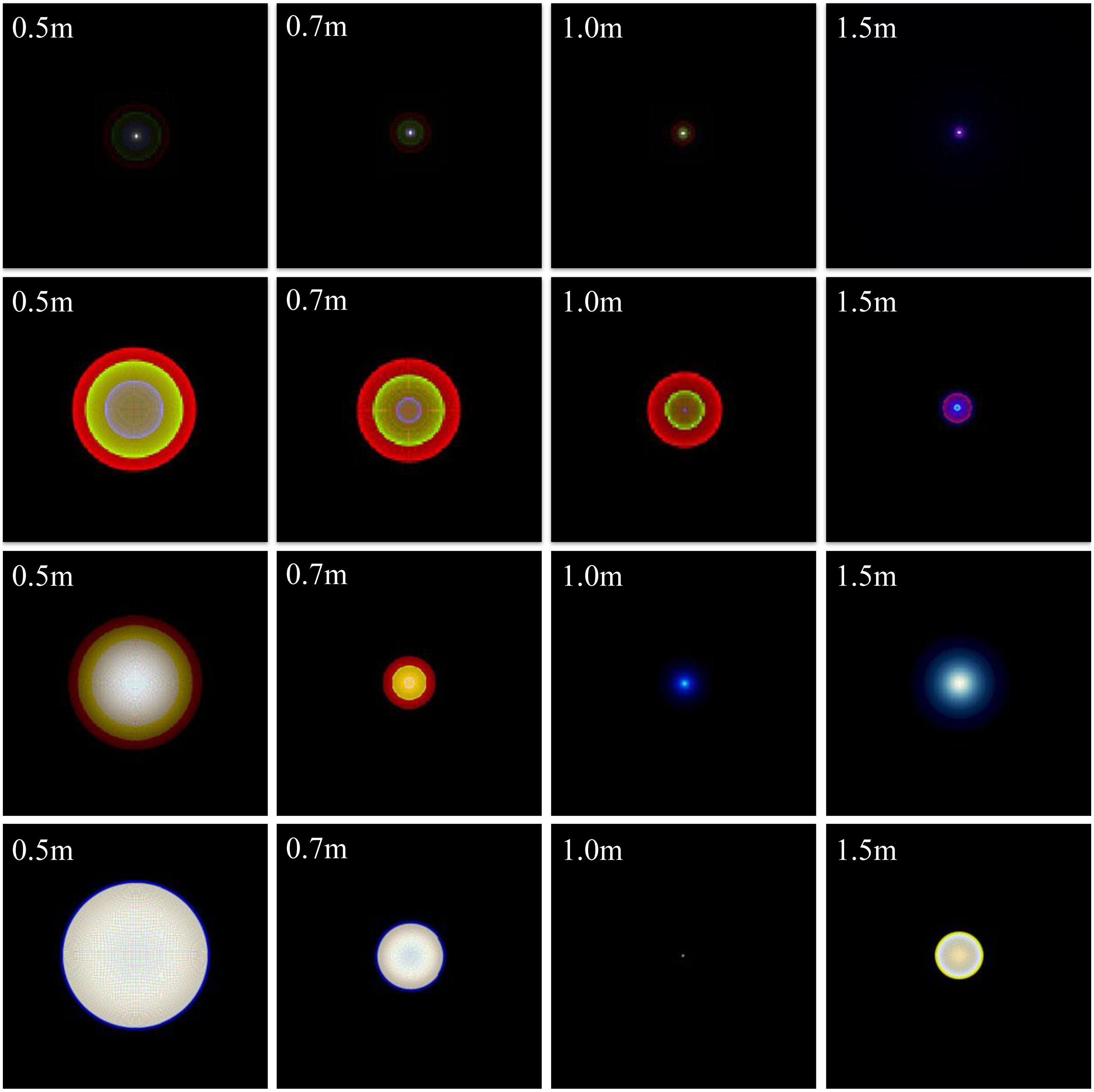

Fig. 2. EDOF performance of the depth performace of optimized lens design (first row) for the application of EDOF, the initial lens design (second row), AL2550-A (third row) and ACA254-050-A (last row)

Fig. 3. Zoomed experimental results 1 for LFOV

Fig. 4. Zoomed experimental results 2 for LFOV with reference at the bottom

Fig. 5. Zoomed experimental results 3 for LFOV with reference at the bottom

Fig. 6. Zoomed experimental results 4 for LFOV with reference at the bottom

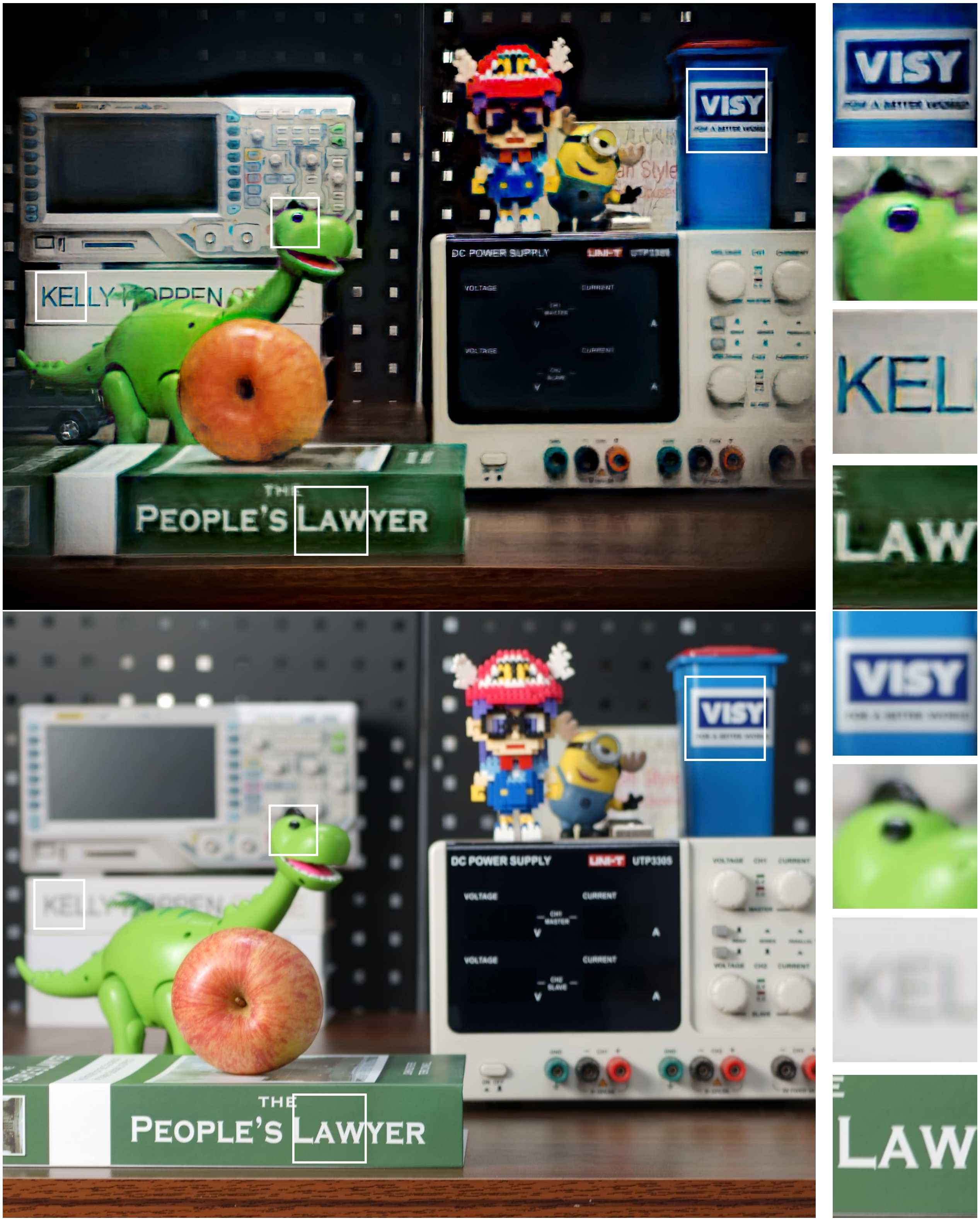

Fig. 7. Zoomed experimental results 1 for EDOF

Fig. 8. Zoomed experimental results 2 for EDOF

Fig. 9. Zoomed experimental results 3 for EDOF