Focal Split

Untethered Snapshot Depth from Differential Defocus

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Project Page

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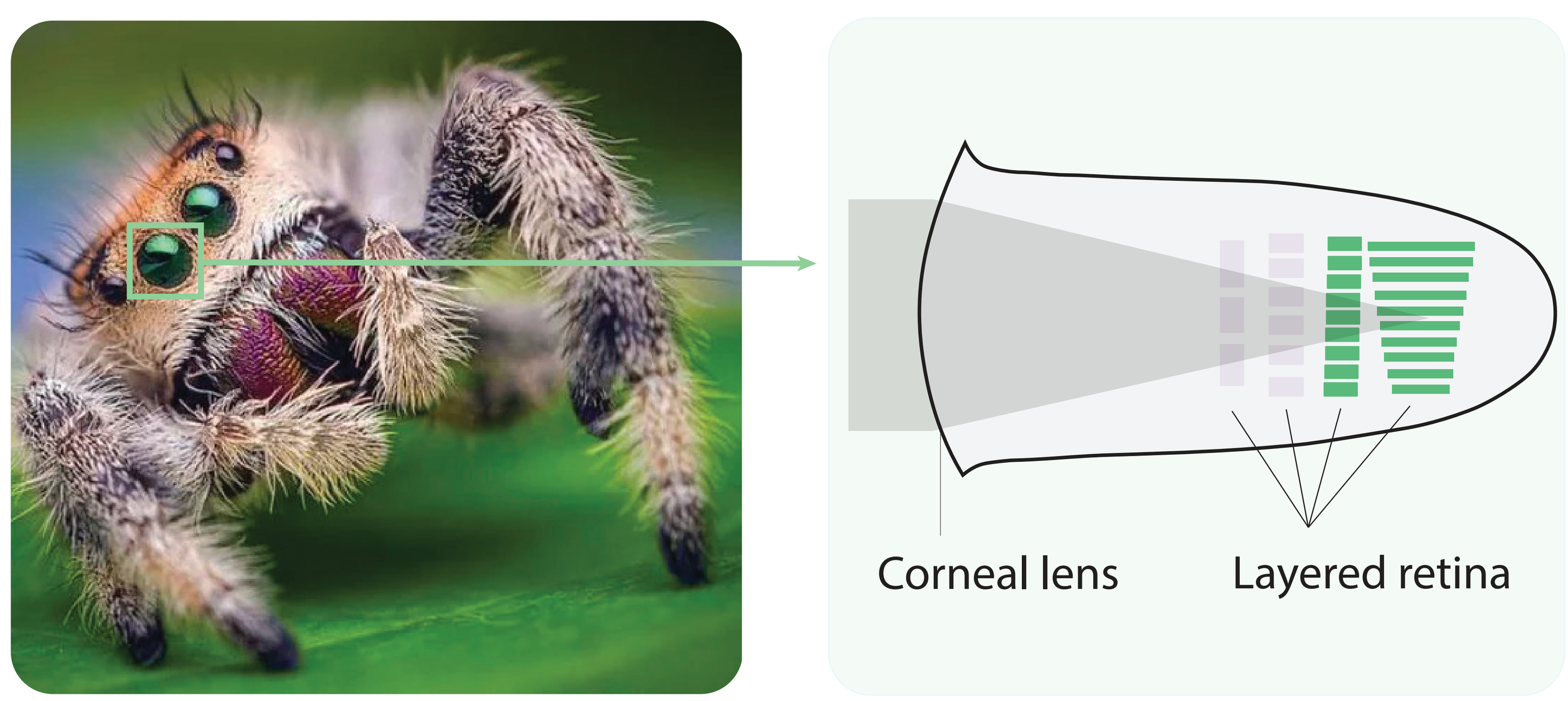
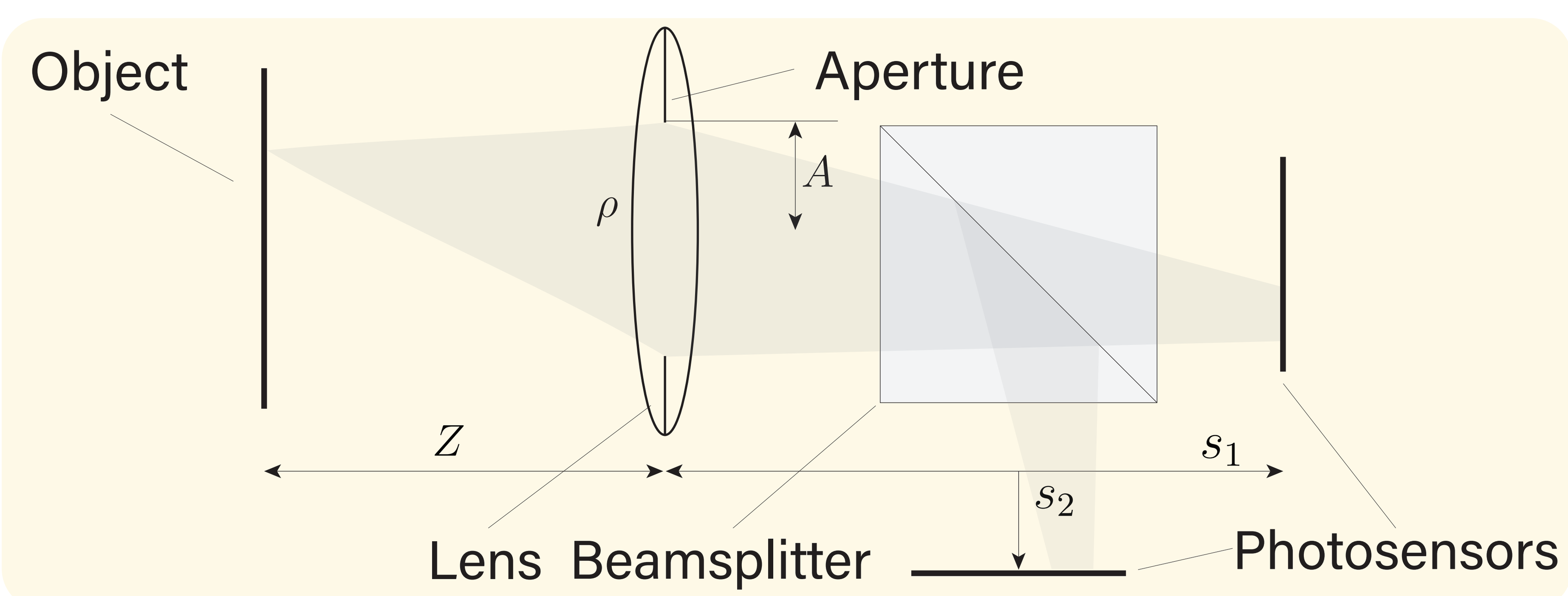
Motivation

Low power, Passive-lighting Depth Sensors

Overview



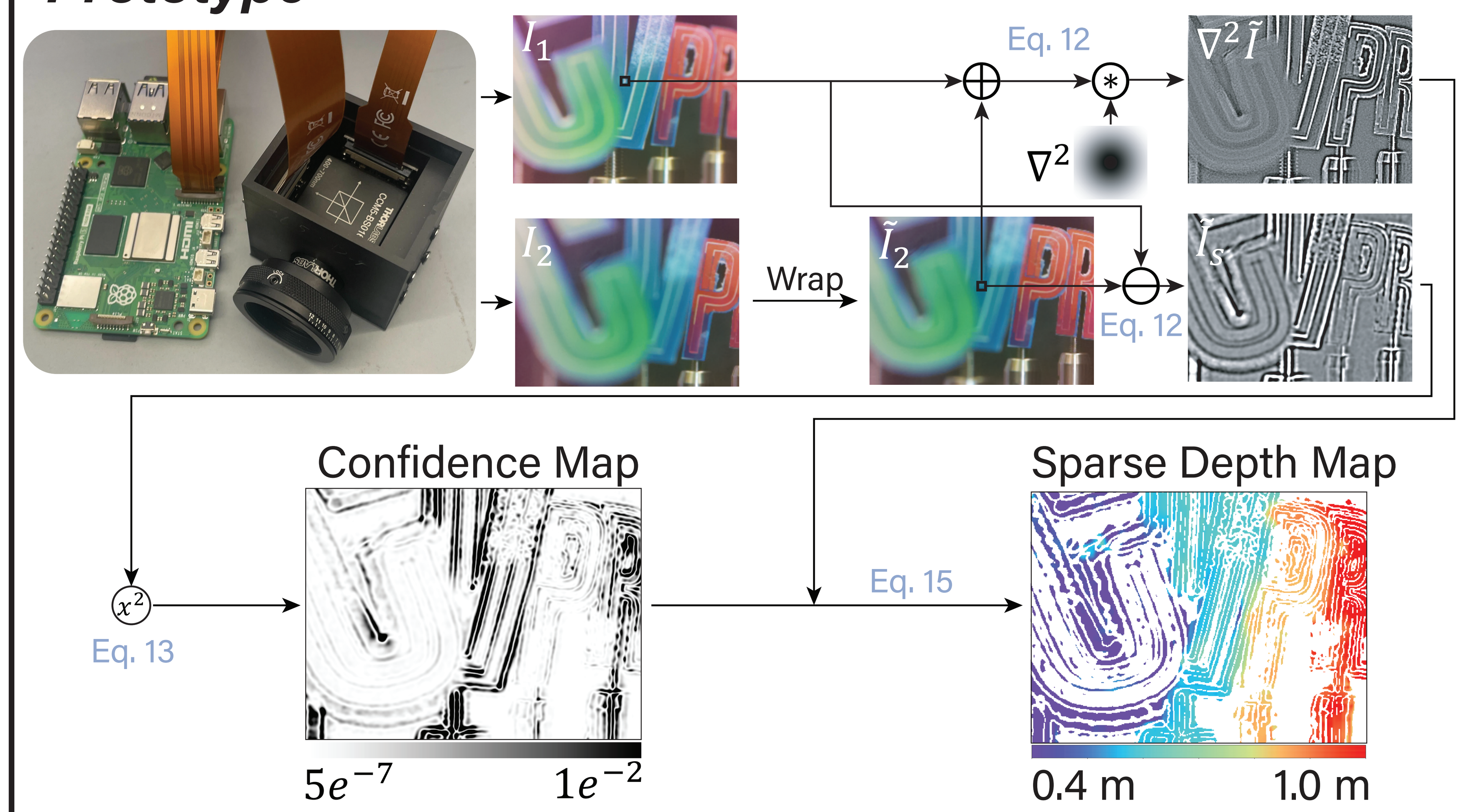


Depth & Confidence

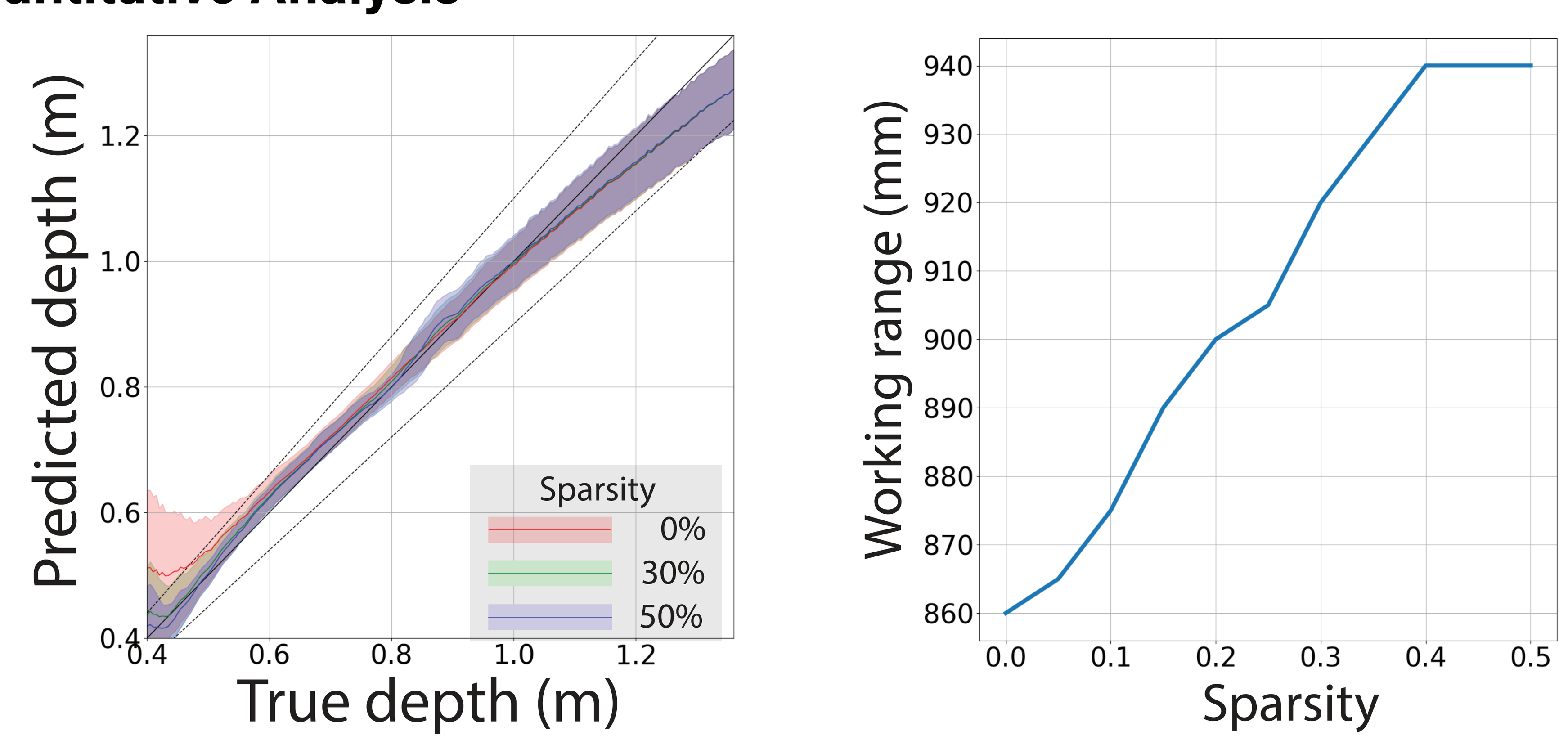
$$Z = \frac{\alpha}{\tilde{I}_s/\nabla^2\tilde{I} + \beta} \qquad C = \tilde{I}_s^2$$

$$\alpha = -A^2 \qquad \beta = -A^2(f^{-1} - s^{-1})$$

Prototype



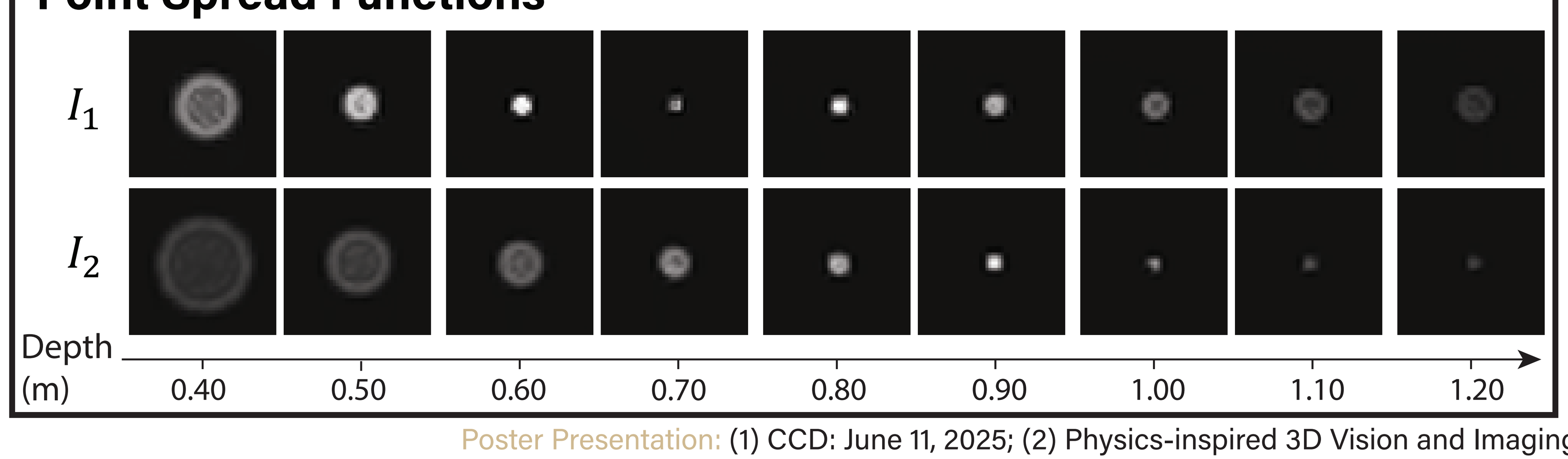
Quantitative Analysis



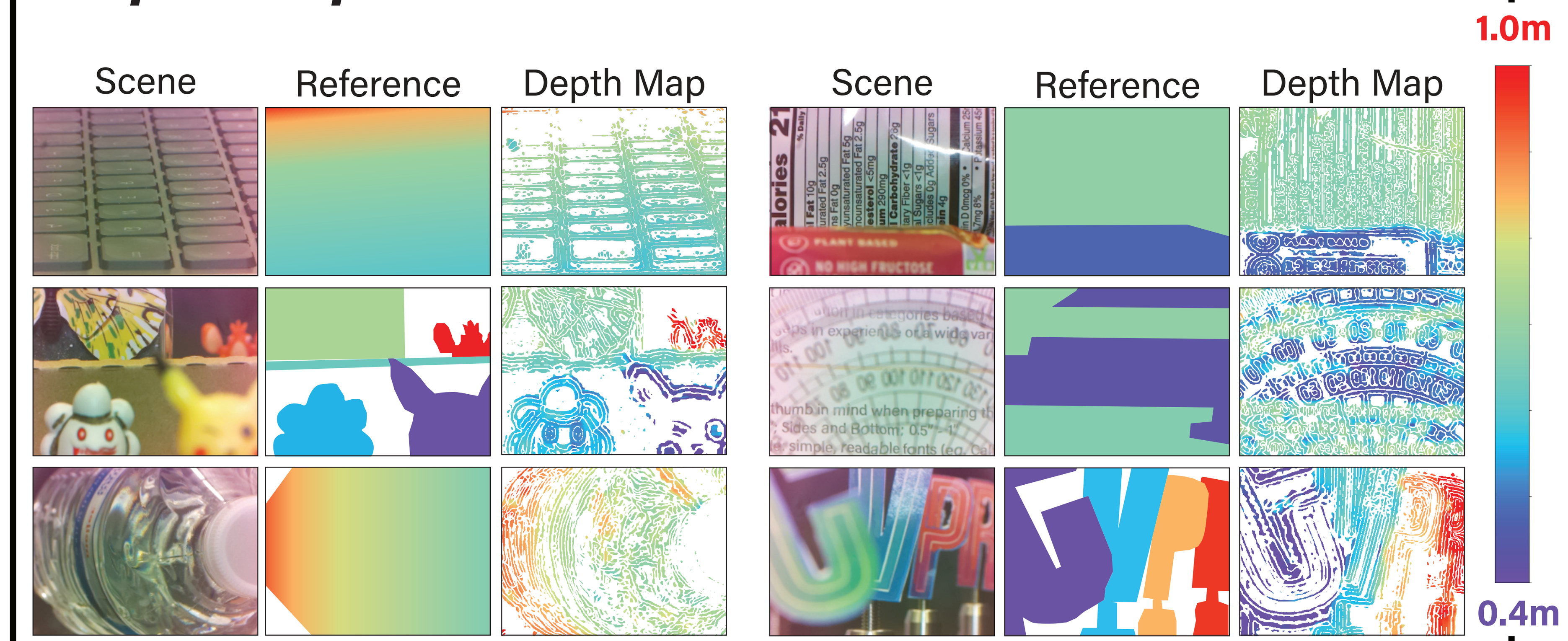
Key Features

- *Snapshot* depth from passive defocus
- Power-efficient (*4.9W* total, battery operable)
- *Real-time* sparse depth map @ *22 FPS*
- DIY-friendly, *open* hardware/software

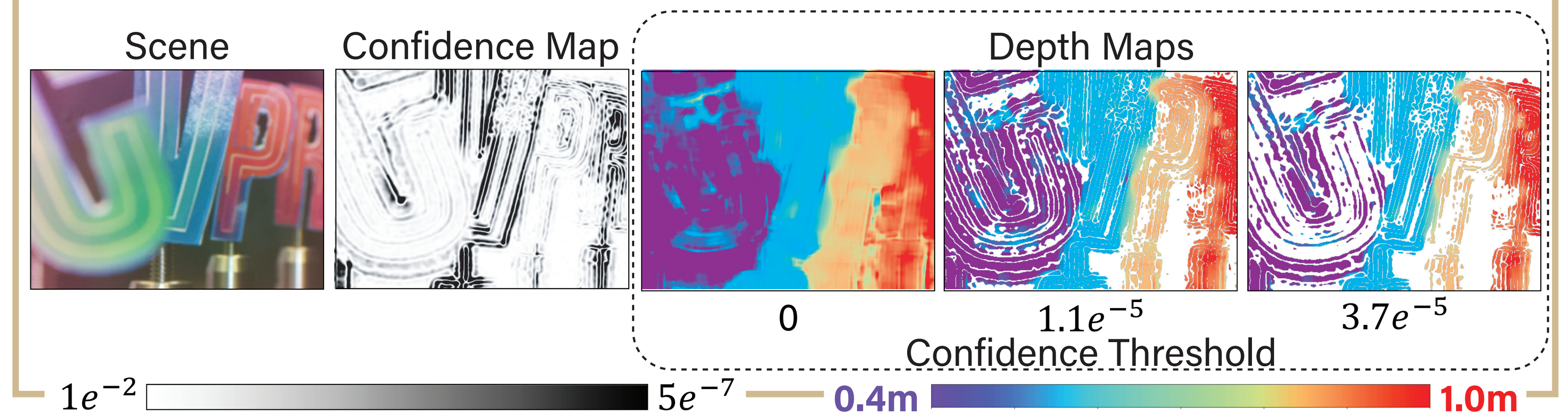
Point Spread Functions



Depth Maps



Confidence



Method Comparison

System level comparison of monocular passive depth imaging techniques. Only ours achieved untethered depth estimation.

Name		# Captures	Resolution	Dense?	Untethered?	Real Time?	Platform / Power
Newcombe et al. 2011.		>10	640 x 480	✓	✗	✓	GTX 480 + i7 CPU
Schonberger et al. 2016.		10,000	Variable	✗	✗	✗	2.7 GHz CPU + 256GB RAM
Tang et al. 2017.	Init	2	5184x3456	✗	✗	Partial	Dual Xeon + 128GB RAM
	Ref	2	2464x3280	✓	✗	Partial	Dual Xeon + 128GB RAM
Alexander et al. 2018.		3	960x600	✗	✗	✓	Xeon X5570 CPU
Haim et al. 2018.		1	1920x1080	✓	✗	✗	Titan X GPU
Ikoma et al. 2021		1	384x384	✓	✗	✓	124 kFLOPs/pixel
Guo et al. 2017.		2	480x300	✗	✗	✓	GTX 1080 + i7 CPU
Luo et al. 2024.		4	480x300	✗	✗	✗	Intel i9-11900K
Ours		1	480x300	✗	✓	✓	RPi 5 (2.4GHz ARM) 500 FLOPs/pixel, 4.9W

Name	Static Scenes		Dynamic Scenes	
	MAE (mm)	Range (m)	MAE (mm)	Range (m)
Alexander et al. 2018.	-	-	179.25	0.600
Tang et al. 2017.	109.97	0.355	316.78	0.145
Guo et al. 2017.	41.82	0.860	107.69	0.295
Ours	41.82	0.860	41.82	0.860

Real-data evaluation: All methods are tested on datasets captured with the Focal Split prototype.

Static scenes: Focal Track matches the proposed snapshot DfD method in both accuracy and working range.

Dynamic scenes: Performance of Focal Track and Tang et al. degrades markedly, while the proposed snapshot method stays consistent.

Focal Flow: Although tailored for dynamic targets, it still delivers lower accuracy and a narrower working range than the proposed approach

Poster Presentation: (1) CCD: June 11, 2025; (2) Physics-inspired 3D Vision and Imaging: June 12 14:50-16:00, 2025; (3) CVPR Demo: June 14 afternoon, 2025; (4) CVPR Poster: June 15 17:00-19:00, 2025