JUNE 18-22, 2023
CVPR
VANCOUVER, CANADA

SeaThru-NeRF:
Neural Radiance Fields in Scattering Media

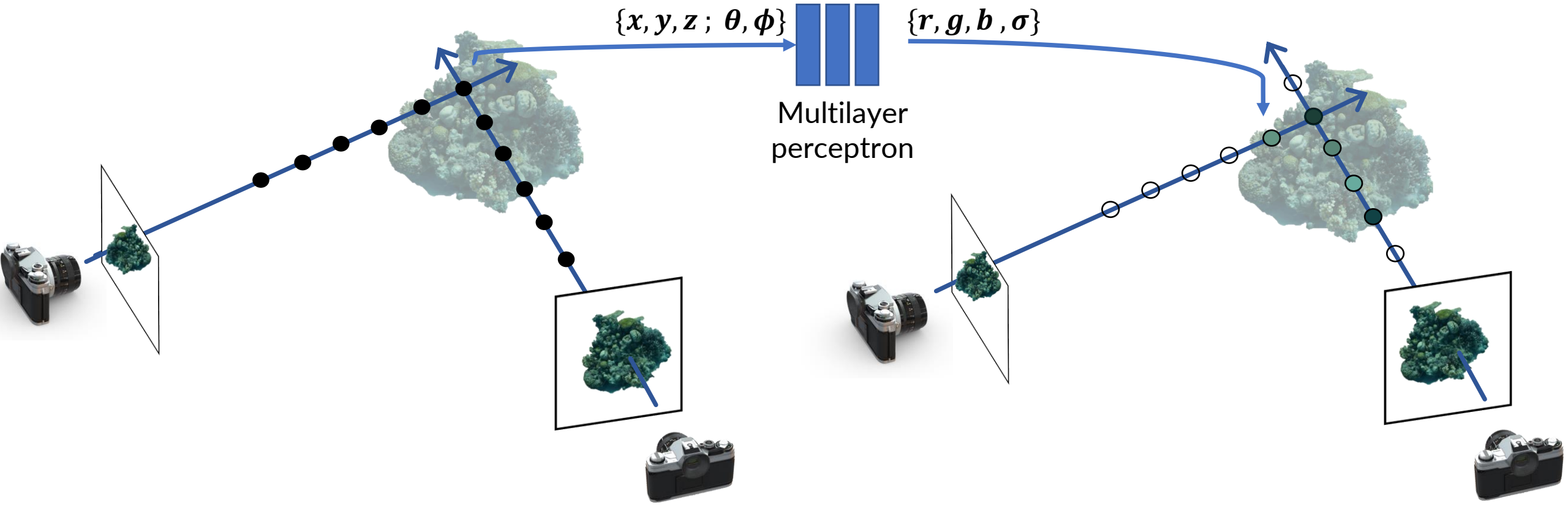
Deborah Levy, Amit Peleg, Derya Akkaynak, Naama Pearl, Dan Rosenbaum, Simon Korman, Tali Treibitz

TUE-AM-006

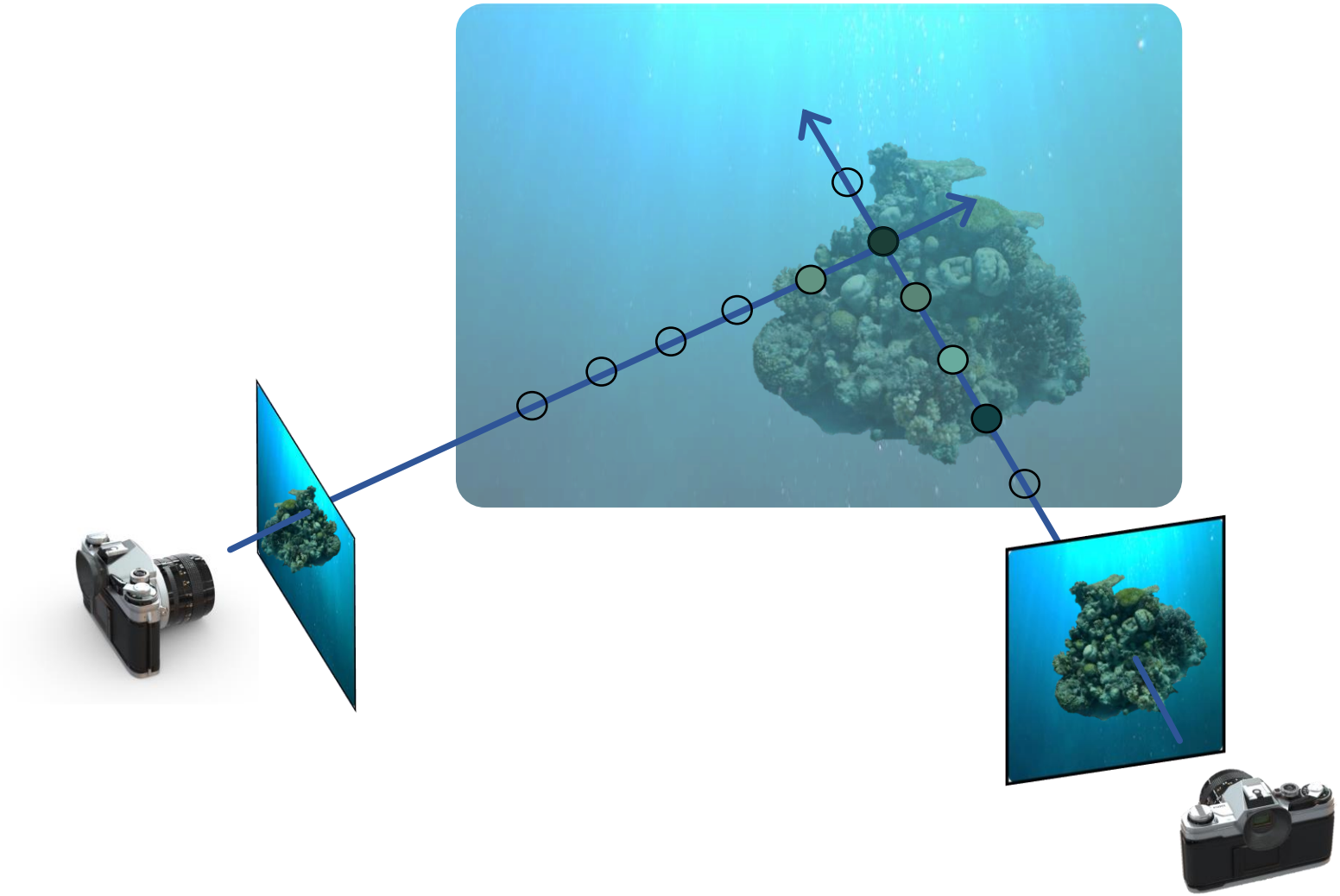
University of Haifa
Department of Computer Science
VISEAON
Treibitz Marine Imaging Lab
LEON H. CHARNEY SCHOOL OF MARINE SCIENCES
The Hatter Department of Marine Technologies

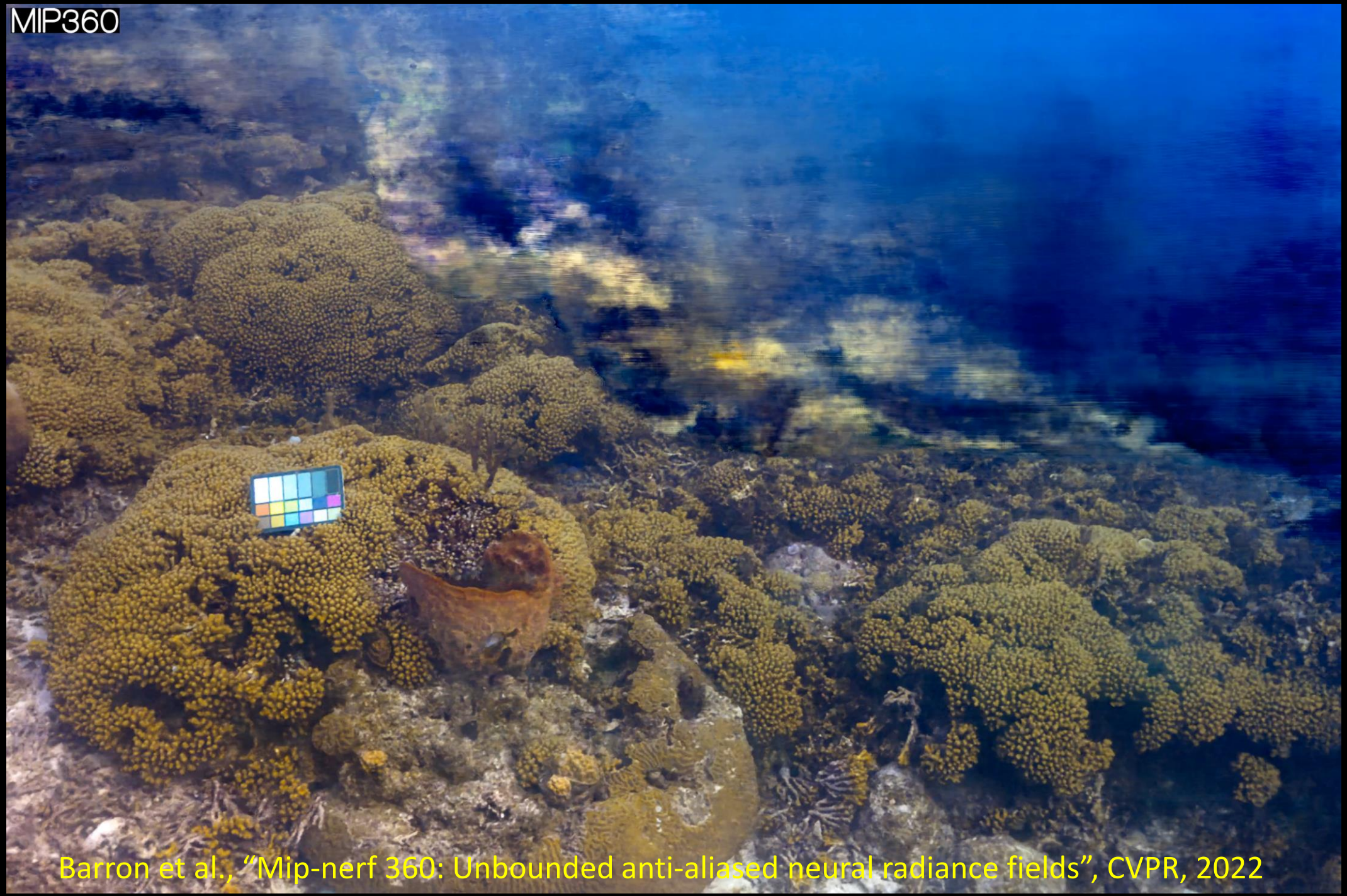
Credit: Matan Yuval

NeRF- Radiance Fields Idea



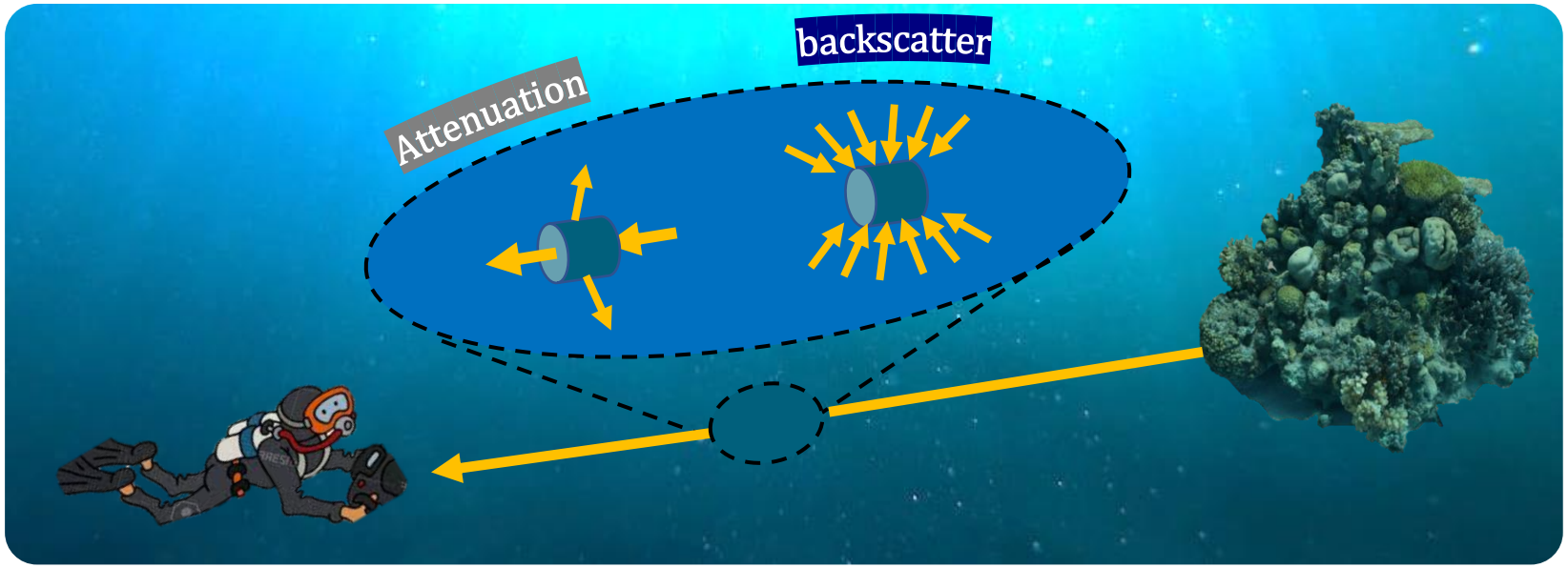
NeRF - The Power to model the medium





Barron et al., “Mip-nerf 360: Unbounded anti-aliased neural radiance fields”, CVPR, 2022

Revised Underwater Image Formation Model



UW Image = Clean Image × attenuation + backscatter

Direct

The attenuation and the backscatter component are not the same

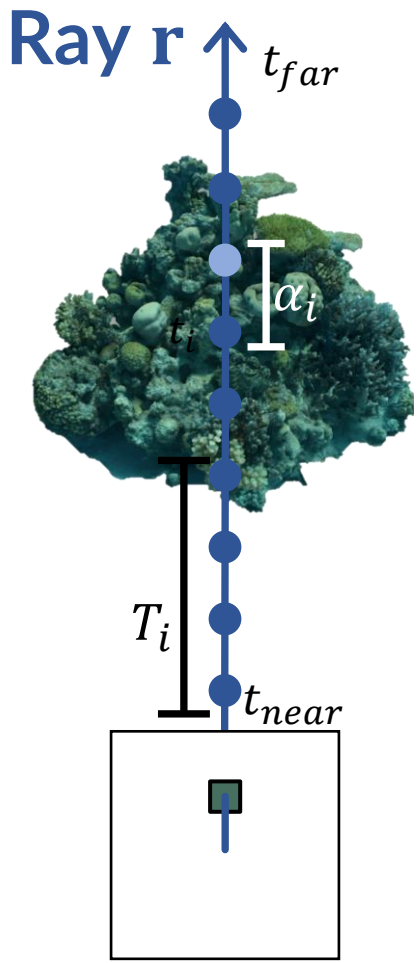
A Revised Underwater Image Formation Model , D Akkaynak and T. Treibitz, CVPR 2018

Nerf – Rendering equations

$$\hat{C}(r) = \sum_{i=1}^{N} T_i \quad (1 - \exp(-\sigma_i \delta_i))\, c_i$$

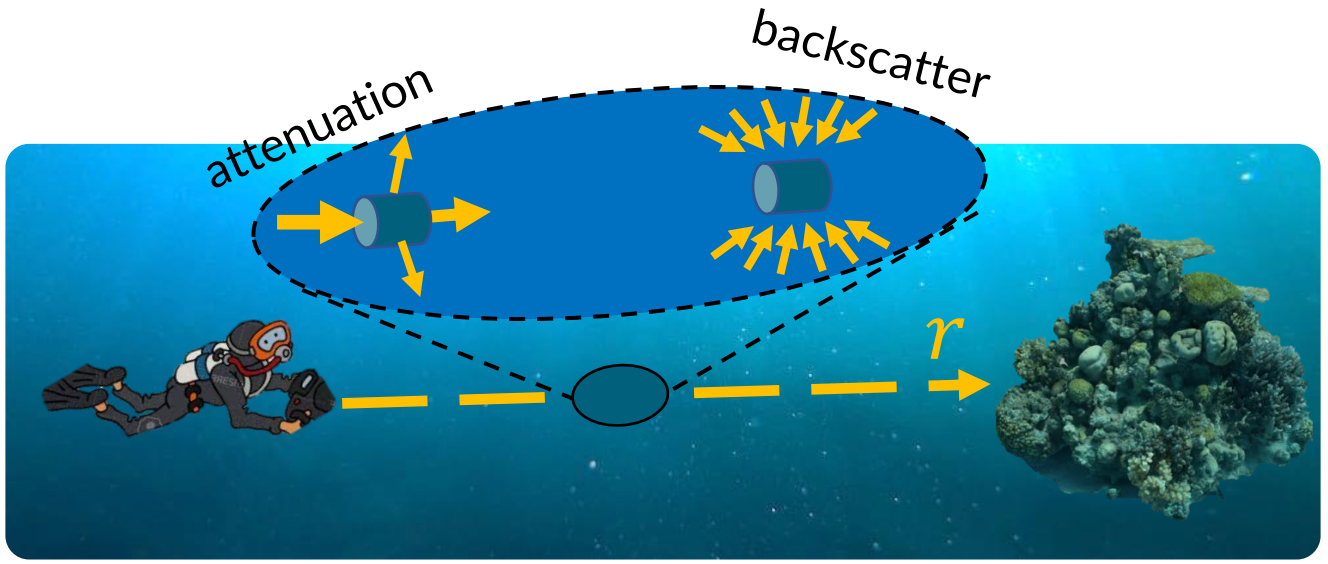
$$T_i = \exp\left(-\sum_{i=1}^{N} \sigma_i \delta_i \right)$$ blocked light earlier along the ray

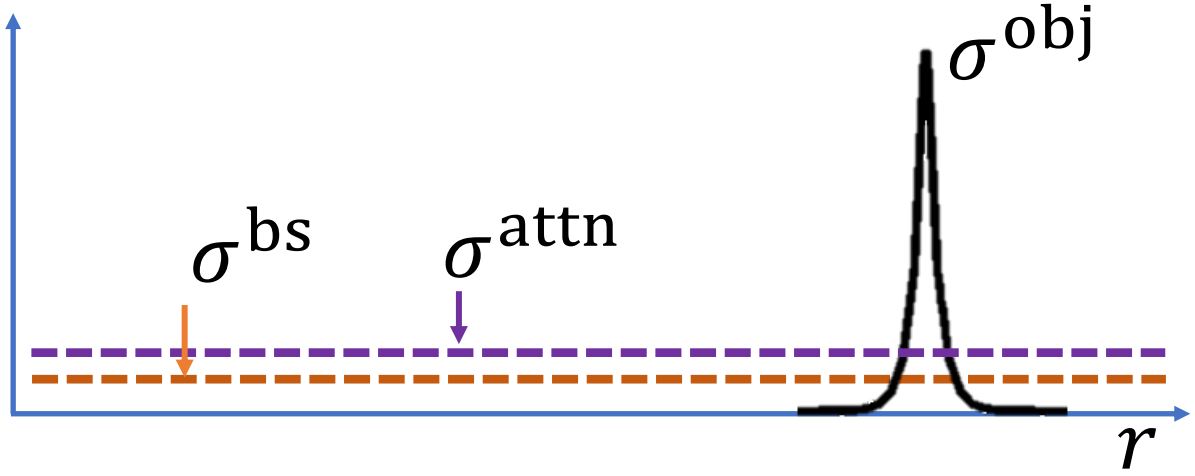
$$\alpha_i = 1 - \exp(-\sigma_i \delta_i)$$ light contributed by ray segment i



3D

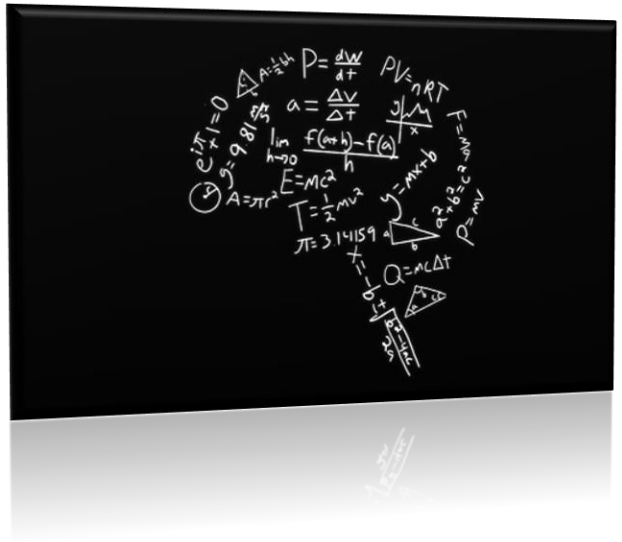
SeaThru-NeRF – Medium Aware Rendering



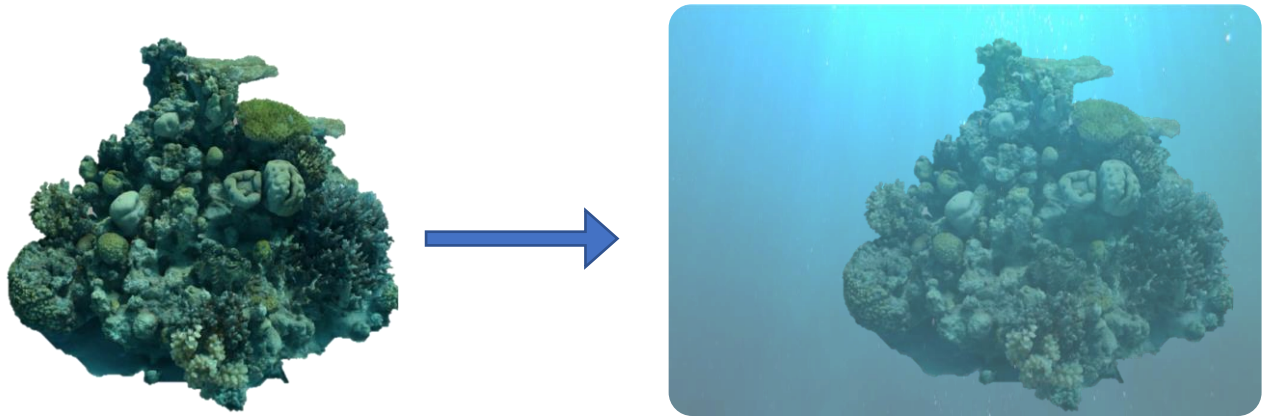


SeaThru-NeRF - Main Contribution

- Novel medium-aware rendering equations



- A medium module in the network's architecture



Novel medium-aware rendering equations

Original NeRF rendering equation

$$\hat{C}(r) = \sum_{i=1}^{N} T_i \left(1 - \exp(-\sigma_i \delta_i)\right) c_i$$

SeaThru rendering equations

UW Image = Clean Image × attenuation + backscatter

$$\hat{C}(r) = \sum_{i=1}^{N} \hat{C}_i^{obj}(r) + \sum_{i=1}^{N} \hat{C}_i^{med}(r)$$

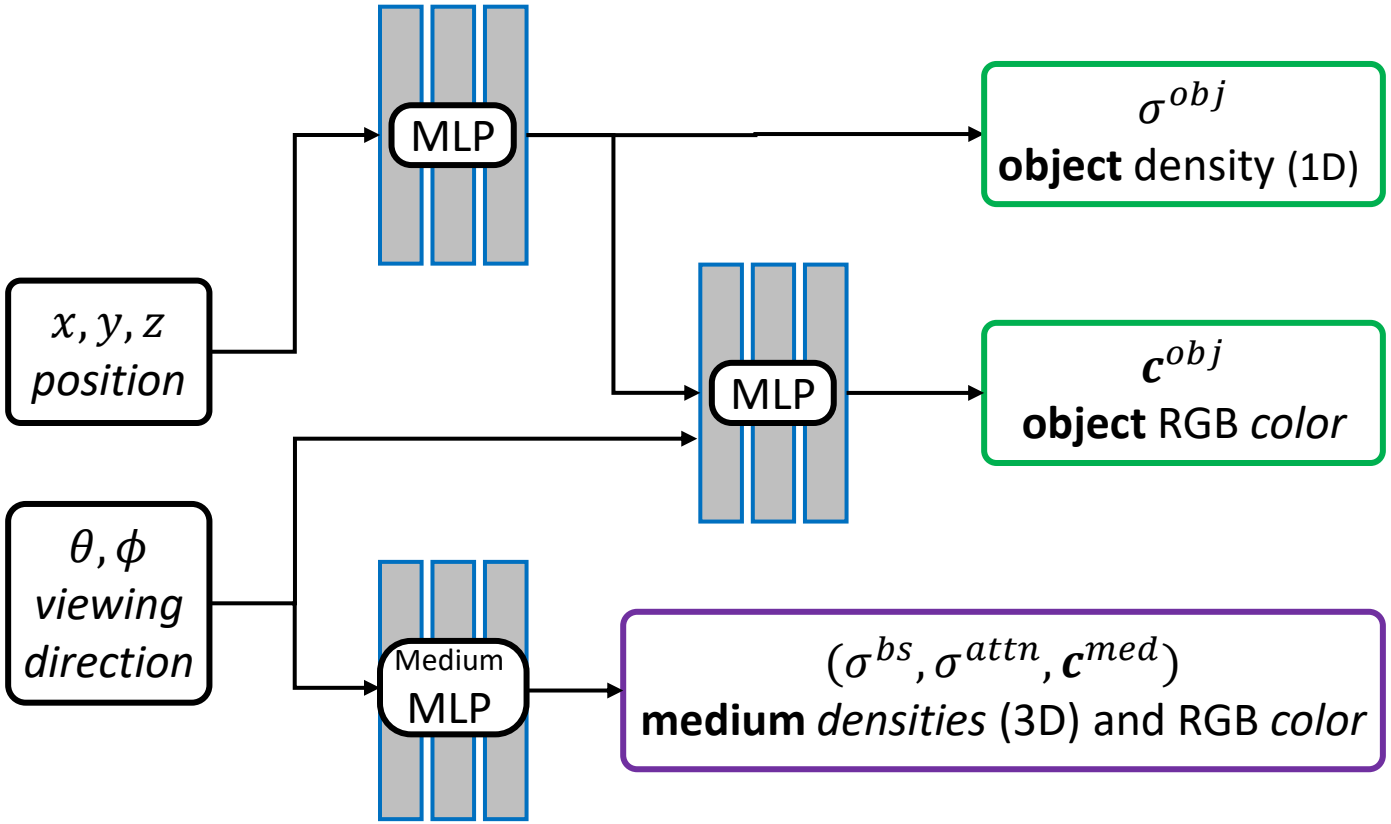
$$\hat{C}_i^{obj} = T_i^{obj} \exp(-\sigma^{attn} s_i) \left(1 - \exp\left(-\sigma_i^{obj} \delta_i\right)\right) c_i^{obj}$$

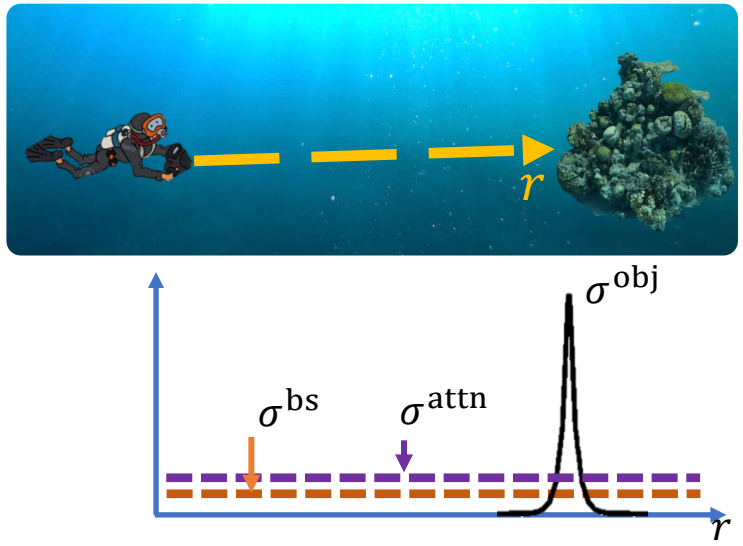
$$\hat{C}_i^{med} = T_i^{obj} \exp\left(-\sigma^{bs} s_i\right) \left(1 - \exp\left(-\sigma_i^{bs} \delta_i\right)\right) c^{med}$$

c^{med} - color of the medium
σ^{bs} - backscatter coefficient
σ^{attn} - attenuation coefficient

} uniform per ray

SeaThru-NeRF – Our Model Architecture





Barron et al., “Mip-nerf 360: Unbounded anti-aliased neural radiance fields”, CVPR, 2022

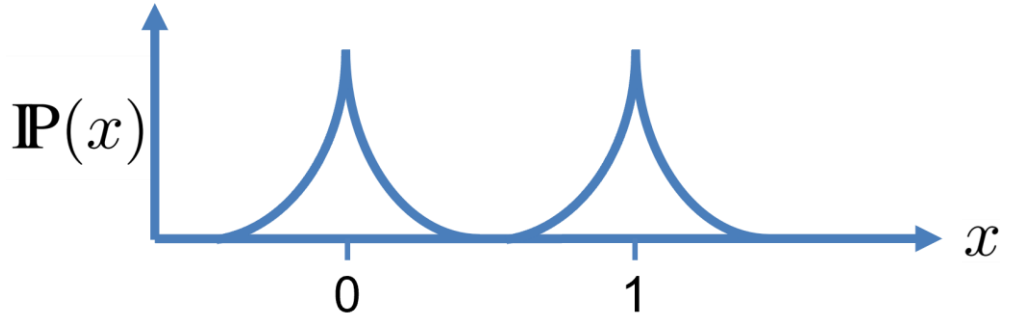
SeaThru-NeRF – Loss function

$$\mathcal{L} = \mathcal{L}_{\text{recon}}(\hat{C}, C^*) + \mathcal{L}_{\text{prop}}(\mathbf{s}, \mathbf{w}) + \lambda \mathcal{L}_{\text{acc}}(\mathbf{w})$$

$$\mathcal{L}_{\text{recon}}(\hat{C}, C^*) = \left(\frac{\hat{C} - C^*}{\text{sg}(\hat{C}) + \epsilon} \right)^2$$

Mildenhall Ben , et al. "NeRF in the Dark: High Dynamic Range View Synthesis From Noisy Raw Images." *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2022.

$$\mathcal{L}_{\text{acc}}(\mathbf{w}) = -\log \mathbb{P}(T_i^{\text{obj}})$$



Rebain, Daniel, et al. "LOLNeRF: Learn from One Look." *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2022.

Credit: Matan Yuval

Credit: Matan Yuval