Learning Neural Reflectance Fields for True Color Correction and Novel-View Synthesis of Underwater Robotic Imagery

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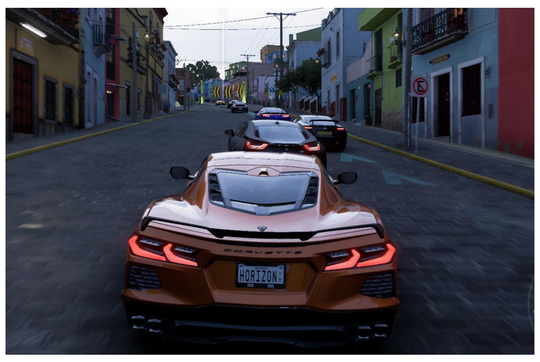
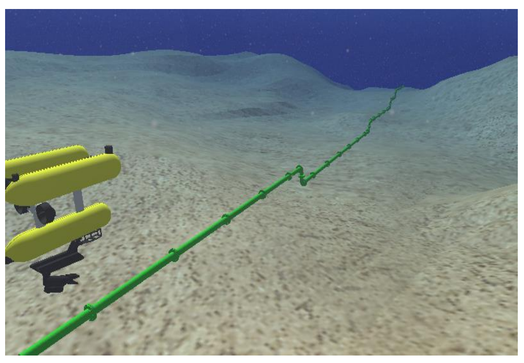
Motivation



Photorealistic Driving Simulation [1]

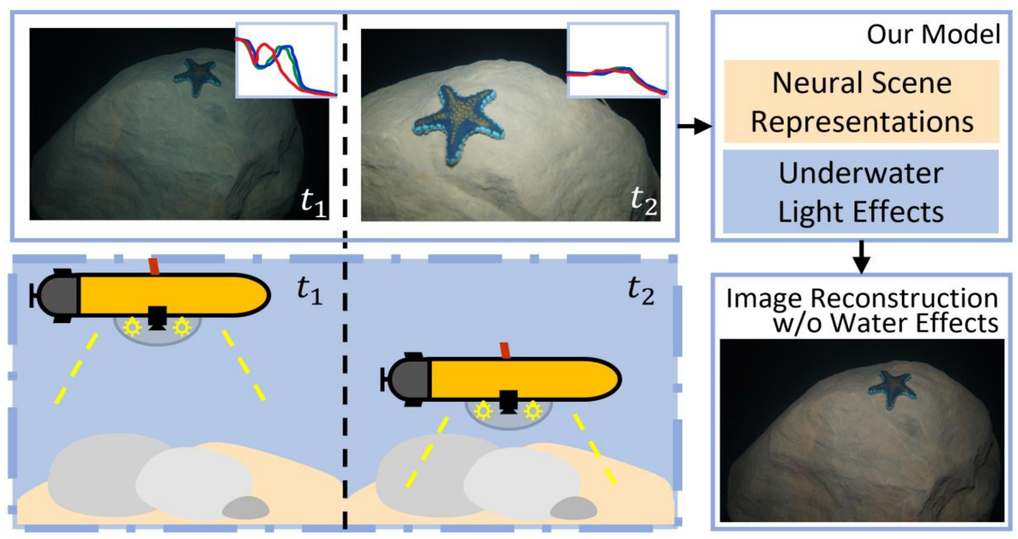


Outdated technologies for underwater Simulation [2]

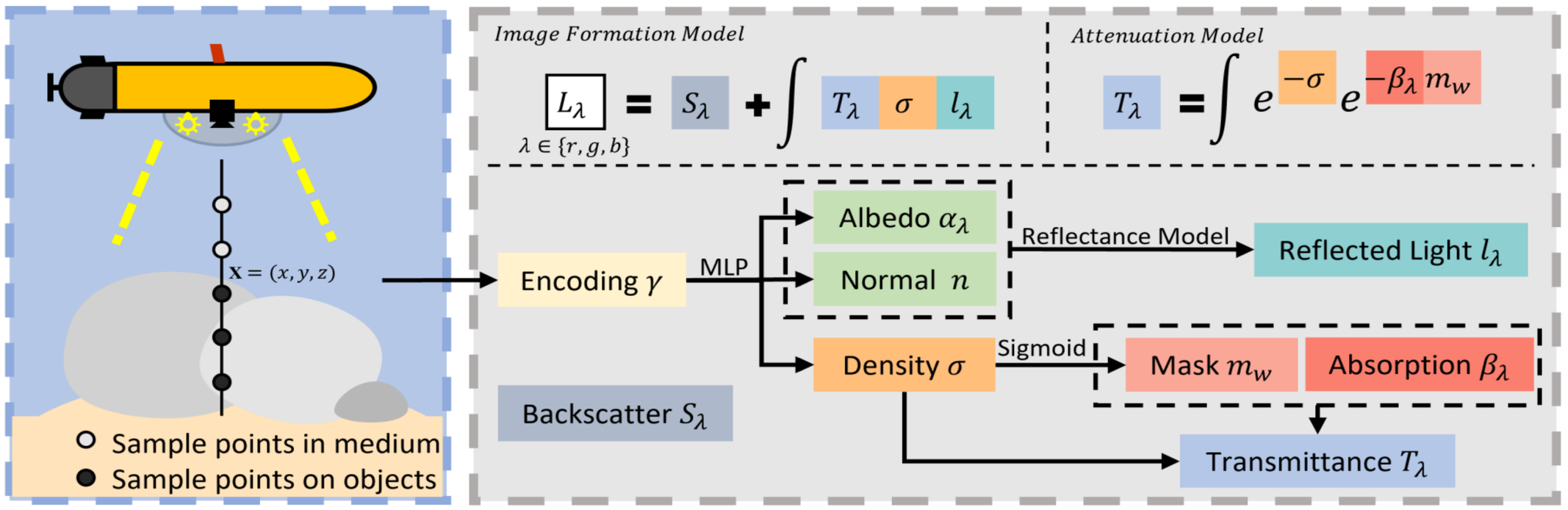
Motivation: We need better underwater simulators

Solution: NeRF (Neural Radiance Fields) and its variants
Main Challenge: Learning water effects together with geometry

What we observe:
Geometry is constrained in multiple view observations, and water effects are encoded in multiple altitude observations. They can be learned together.

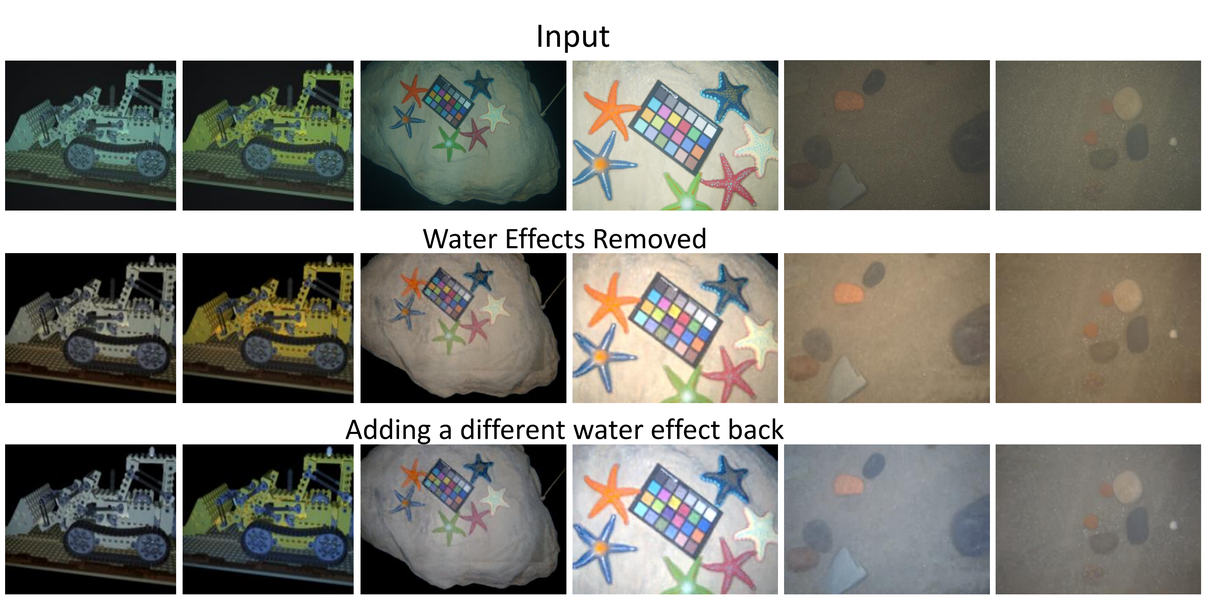


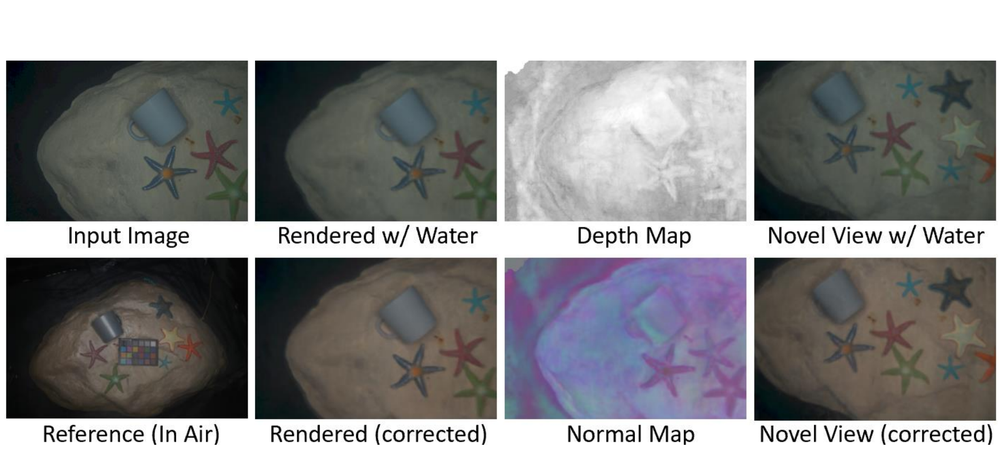
Methodology



Our proposed method: Learning geometry, reflectance property, water effects (attenuation, backscatter) in a unified model, based on neural reflectance field [3] and Jaffe-McGlamery Model [4].

Results & Visualization





Takeaways

- We can learn neural reflectance field + water effects as a unified model
- True color can be corrected without pretraining, without depth estimation, without color assumptions (grayworld [5], dark channel [6], etc.)
- Then we can add arbitrary water effects back
- And of course, we can render novel views since it's NeRF-based.

Limitations & Future directions

- Single point light source -> Mixed light source / ambient light
- Backscatter modeled as a constant -> Better approximation of backscatter

Reference
[1] Forza Horizon 5, Xbox Game Studios
[2] Prats, M.; Perez, J.; Fernandez, J.J.; Sanz, P.J., "An open source tool for simulation and supervision of underwater intervention missions"
[3] Bi, Sai, et al. "Neural reflectance fields for appearance acquisition." arxiv 2020.
[4] Jaffe, Jules S. "Computer modeling and the design of optimal underwater imaging systems." IEEE Journal of Oceanic Engineering 15.2 (1990): 101-111.
[5] G. Buchsbaum, "A spatial processor model for object colour perception," Journal of the Franklin institute, 1980
[6] K. He, J. Sun, and X. Tang, "Single image haze removal using dark channel prior," in 2009 CVPR

Publication

T. Zhang and M. Johnson-Roberson, "Beyond NeRF Underwater: Learning Neural Reflectance Fields for True Color Correction of Marine Imagery," in *IEEE Robotics and Automation Letters 2023*

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