Collaborative Research: NRI: INT: Cooperative Underwater Structure Inspection and Mapping

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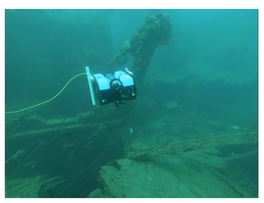
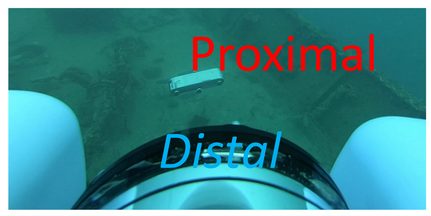


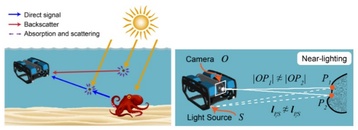
Problem: Underwater mapping with a team of underwater robots
Main idea: a team of co-robots collaborating with a human operator, in particular **proximal observer**, which will operate close to the structure to map, and **distal observer**, which will be at distance maintaining the global picture of the structure and the pose of the proximal observer.



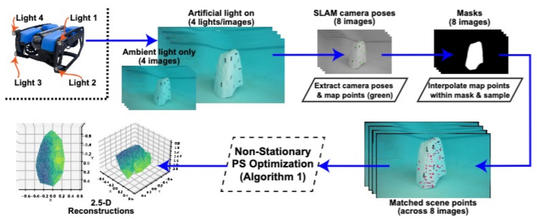
The underwater domain poses unique challenges, including absence of localization systems (e.g., GPS) and communication infrastructure (e.g., WiFi).
This collaborative research funded under the NSF-NRI program has the objective to address such challenges, answering to four important Research Questions:
(RQ1) How to robustly achieve cooperative localization with occlusions?
(RQ2) How to fuse the different sources of information on-board in real time for reconstruction?
(RQ3) How should the co-robots cooperate for the mapping task?
(RQ4) How to efficiently and robustly use limited resource communication channels to share information between a team of robots and between robots and operator?

Monika Roznere (PhD student, Dartmouth)

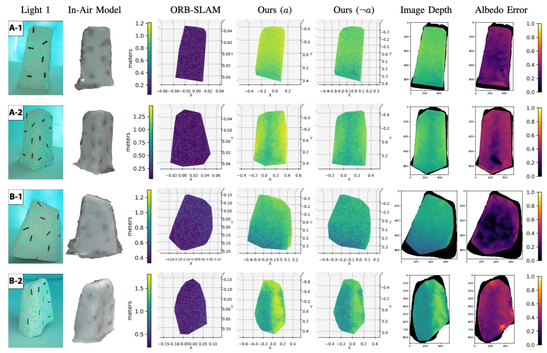
Recent contribution: inexpensive 3D reconstruction

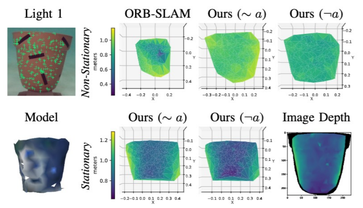


Camera + lights
Photometric Stereo (PS) Solution
in non-stationary scenario



Proposed pipeline

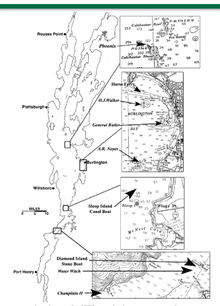




Our PS framework successes
detected the correct shape
estimated accurate depth
relatively smooth results

"3-D Reconstruction Using Monocular Camera and Lights: Multi-View Photometric Stereo for Non-Stationary Robots", ICRA 2023

The project will have **broader impacts** in several high-impact applications, including infrastructure inspection and archaeological sites mapping.



Lake Champlain, VT, shipwreck map where we did some deployments

The overall **intellectual merits** of this project will be in several areas of computer vision, robotics, learning, and communication, including:

- Robust state estimation and cooperative localization, fusing several sensors.
- Cooperative exploration and planning of underwater vehicles in the presence of obstacles
- Cross-layer optimization approach for transmitting reconstructed models and vehicle positions under limited communication resources.

Having such a team of robots allows for **lowering the barrier to entry in underwater robotics**, as the robot design can be simplified by complementing their capabilities.

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