UNIVERSITY OF SOUTH CAROLINA

CSCE 574 ROBOTICS

Introduction

Ioannis Rekleitis

Why Robotics?

- Manufacturing
- Labor shortage (agriculture, mining)
- Point where computers fast/cheap
- Automation of cars→more cars on highways
- To reach areas where no human can go

Present Everywhere

- **At home**
- On the road
- In the sky (drones)
- In the fields
  (agricultural robotics)
- In resource utilization
  (ROV in the oil industry)
- Along power lines
- In Hospitals
- Education
- In Factories
- In Warehouses
- In Space

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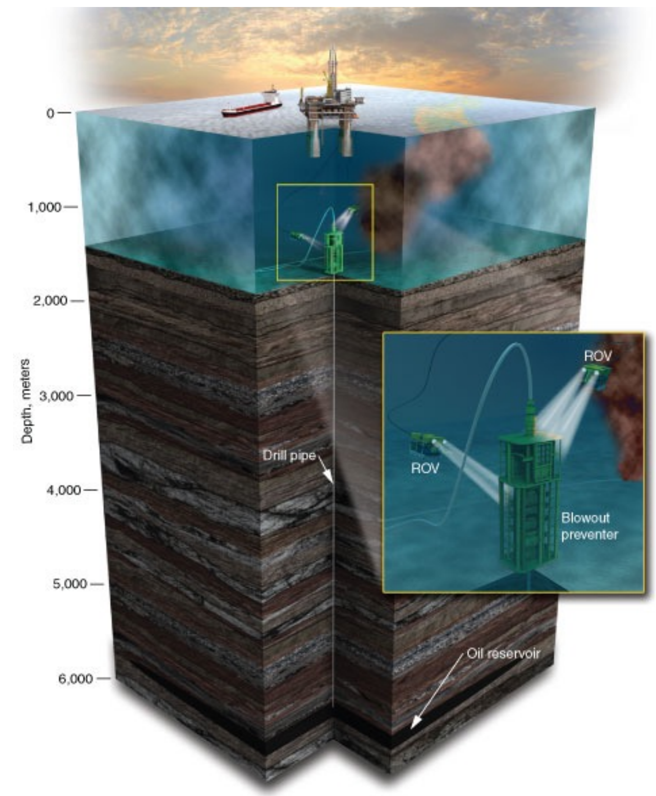

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- Education
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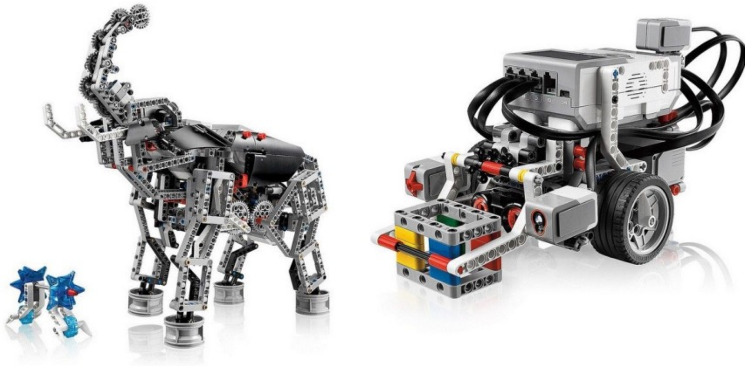

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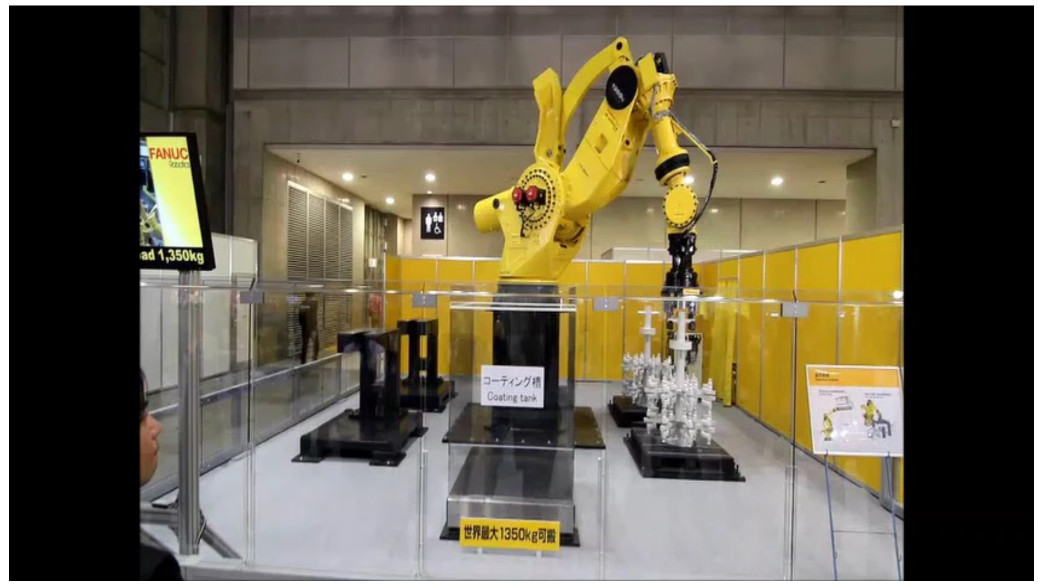

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- **In Warehouses**
- In Space

Amazon bought Kiva for $775M

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- **In Space**

Robotic technology becomes affordable

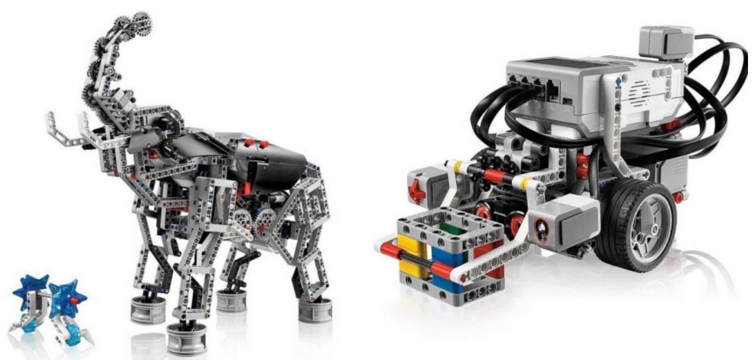
TurtleBot 2

AR.DRONE

Kinect

IMU

Raspberry Pi

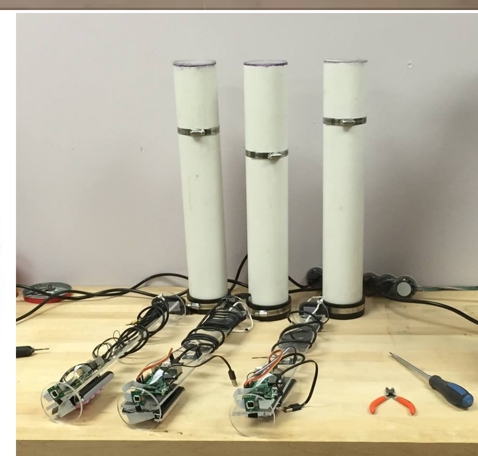


Lego Mindstorm

GPS

Robotics at USC

Courses	Professors
CSCE 274	Dr. **Rekleitis**
CSCE 574	Dr. Vitzilaios (ME)
CSCE 774	Dr. Wang (EE)
CSCE 790	



Autonomous Field Robotics Lab

Autonomous Field Robotics Lab

Syllabus

Week 01: Syllabus presentation, Round Table, Introduction, History of Robotics. ROS
Week 02: Actuators. Locomotion. Sensor (Tactile, Range Finders, GPS, IMU, Position Encoders).
Week 03: Reactive Path Planning. Potential Fields. State Estimation,
Week 04: Bayesian Filtering Particle Filters
Week 05: Kalman Filters
Week 06: Exploration, HRI
Week 07: Mapping: Metric Maps, Topological Maps, hybrids
Week 08: Visibility Graphs, Bug Algorithm, Generalized Voronoi Graphs, Atlas.
Week 09: Coordinates, Control
Week 10: Semantic hierarchy of spatial representations. Configuration Space, PRMs
Week 11: Architectures.
Week 12: Coverage, Multi-Robot Coverage
Week 13: Learning in Robotics
Week 14: Sensor (Vision).
Week 15: Review of Material

Evaluation

- 5 Assignments, 10% each: 50%
  - First two individual
  - Last three 50% team, 50% individual
- Final Examination: 25%
- Midterm: 15%
- Homework (5) 10%
- Graduate students/honors etc. one extra assignment
  - Bibliography search
- **Robot programming assignments: -10% per day for the first 3 days. Then no submission.**
- Assignments and homeworks should be submitted to the CSE Moodle server by the deadline (https://dropbox.cse.sc.edu), where grades will be posted on.

Homeworks/Projects

- Using ROS
- Using Simulations
- Using sensor data from real robots
- Using real robots (TurtleBot 2)

How to do poorly

Here are some habits that have correlated with poor performance in this course in the past:

- **Not starting/making progress on the programming assignments until the last minute**
- Skipping class
- Ignoring the communications from the instructor
- Not properly reading the instructions
- Ignoring the homework
- Not asking questions and interacting with the instructors

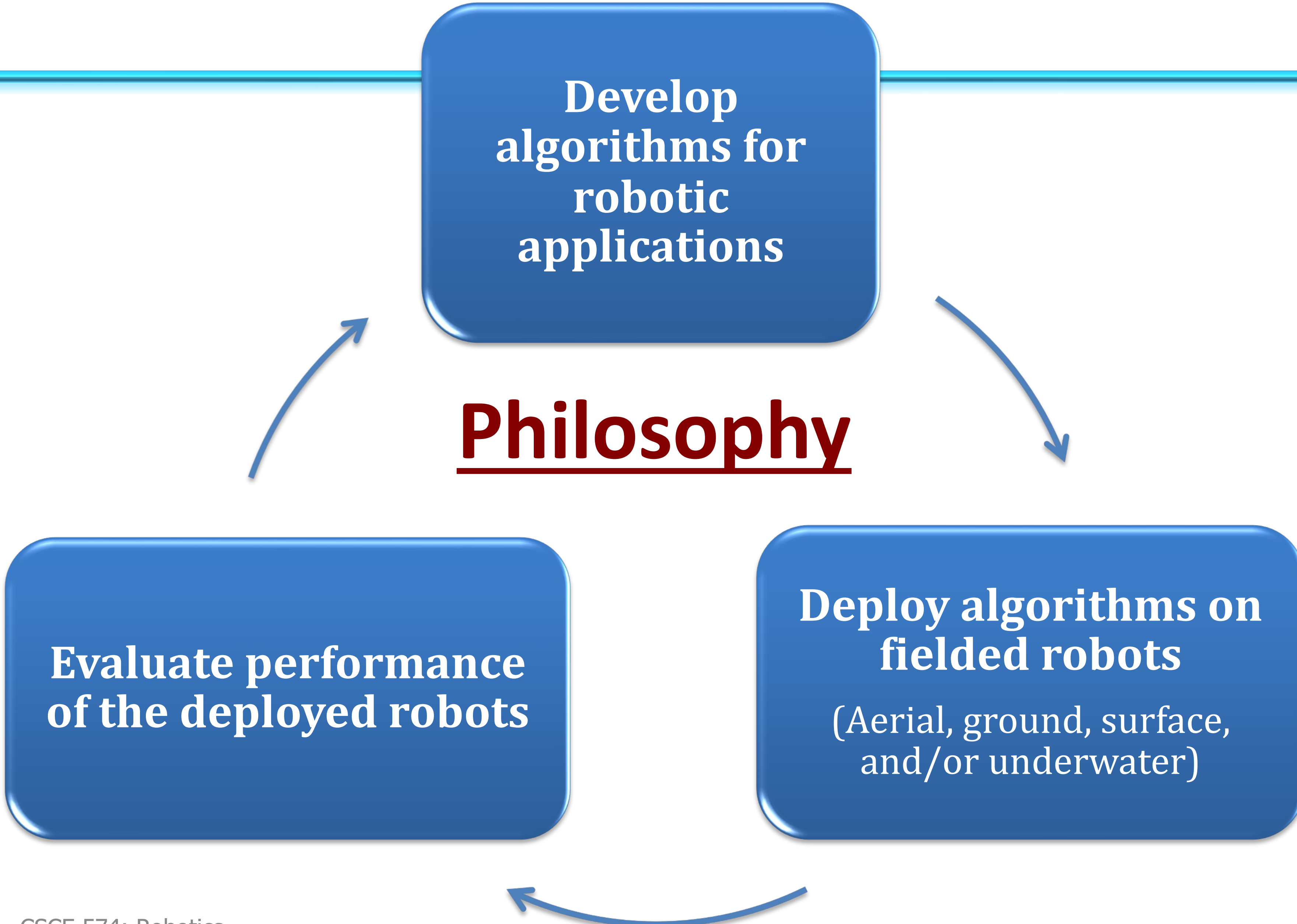
Contact

- http://www.cse.sc.edu/~yiannisr/
- http://www.cse.sc.edu/~yiannisr/574/2023Spring/
- **Email**: yiannisr@cse.sc.edu

- **Office hours**: 2235– Mon/Wed 13:00-14:10

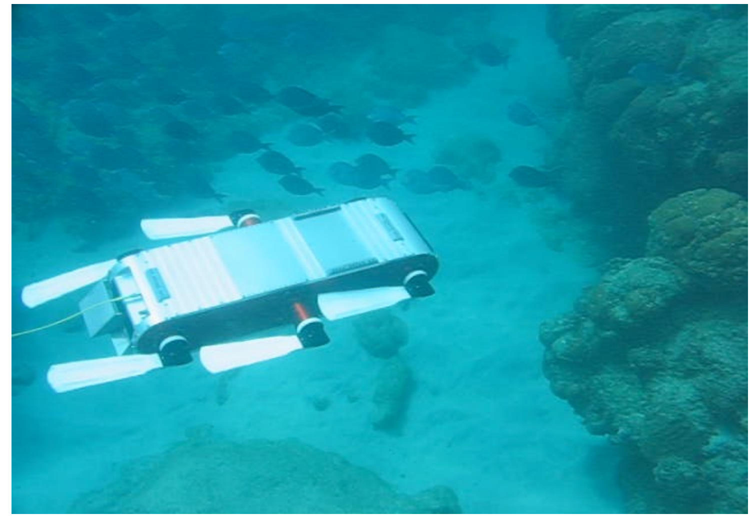
  and by appointment

Philosophy


Develop algorithms for robotic applications
Deploy algorithms on fielded robots
(Aerial, ground, surface, and/or underwater)
Evaluate performance of the deployed robots

Recent Funding:

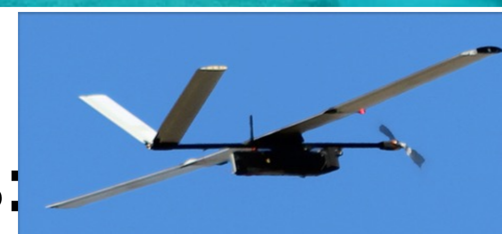
- **NSF CRI II-New**: Acquisition of a Heterogeneous Team of Field Robots for Coastal Environments
- **PI: I. Rekleitis.**
- CoPIs: J. Beer, J. O'Kane



Several **Surface Vehicles**

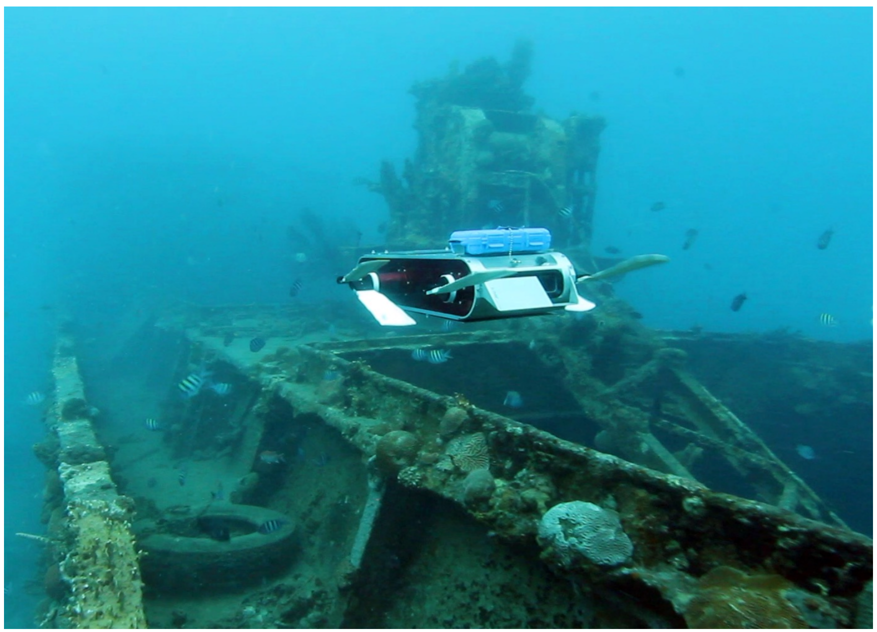
2 **Aqua** u/w vehicles

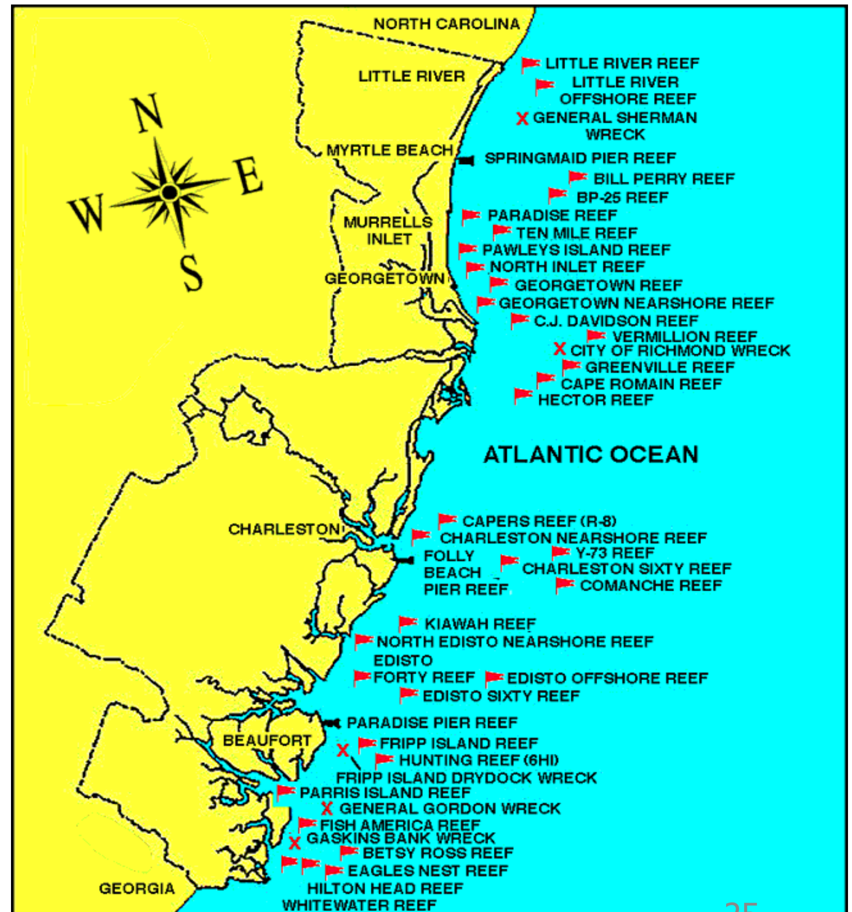
Aerial Vehicles:
2 fixed wings
2 quadrotor



Recent Funding:

- **Google Faculty Research Awards**: Underwater Street View: Wreck Mapping off the Carolinas
- **PI**: I. Rekleitis
- 2016-2017



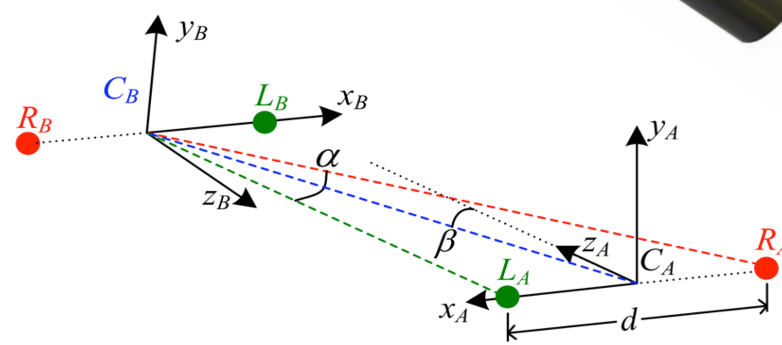


Recent Funding:

- **NSF NRI**: Enhancing Mapping Capabilities of Underwater Caves using Robotic Assistive Technology
- **PI**: I. Rekleitis
- **Funding**: 2016-2019

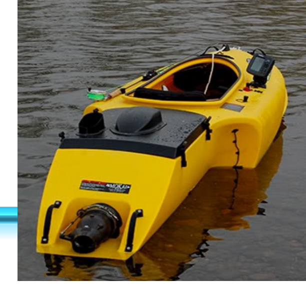
SONAR-Vision Fusion

Stereo Based 3D Reconstruction

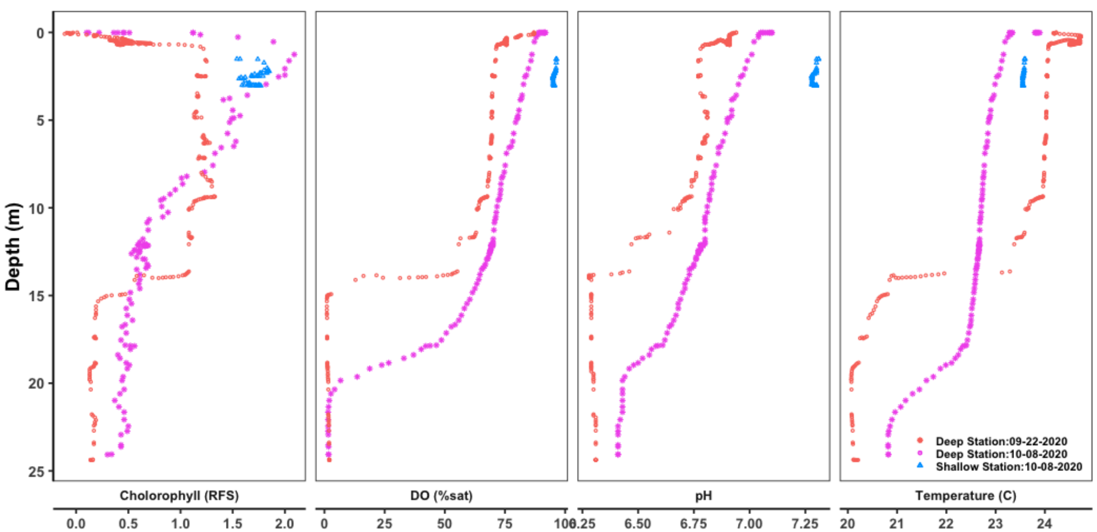


Cooperative Localization

Recent Funding:

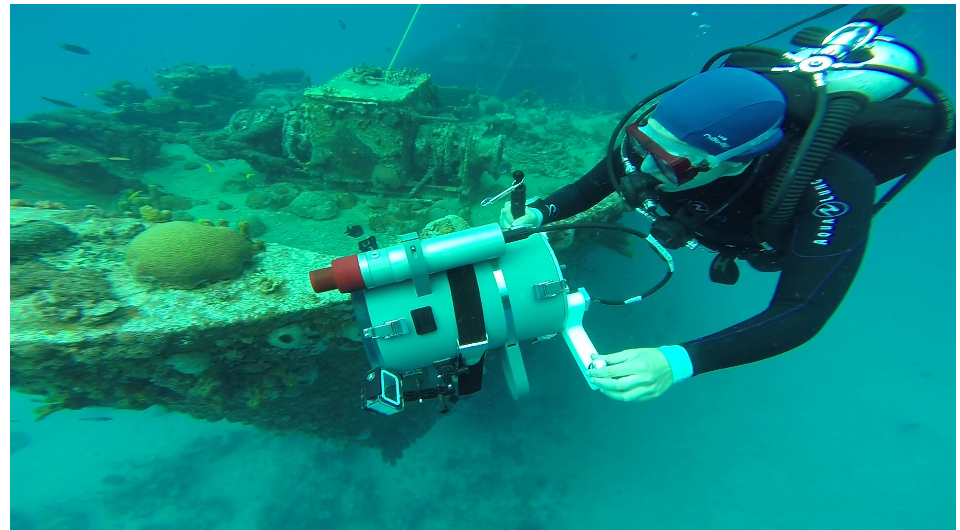


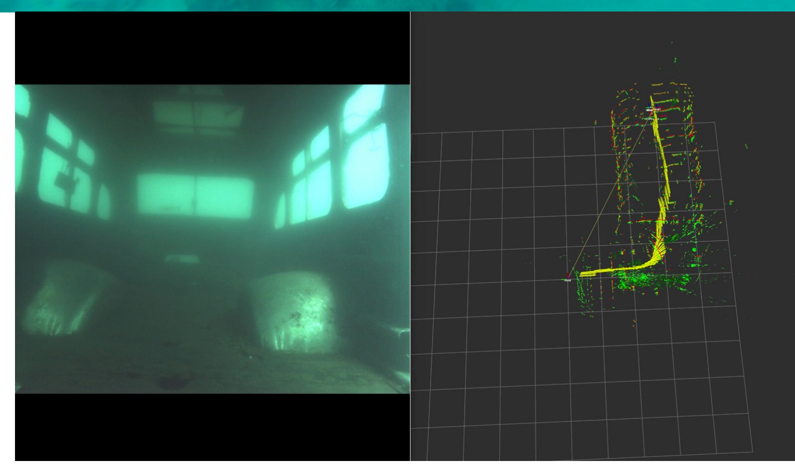
- **NSF RII Track-2 FEC:** Computational methods and autonomous robotics systems for modeling and predicting harmful cyanobacterial blooms.
- **Funding**: 2019-2023



Recent Funding:

- **NSF CAREER:** Enabling Autonomy via Enhanced Situational Awareness for Underwater Robotics
- **Funding**: 2020-2025





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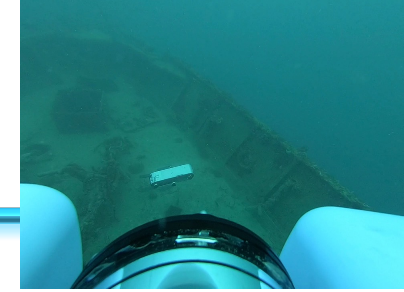
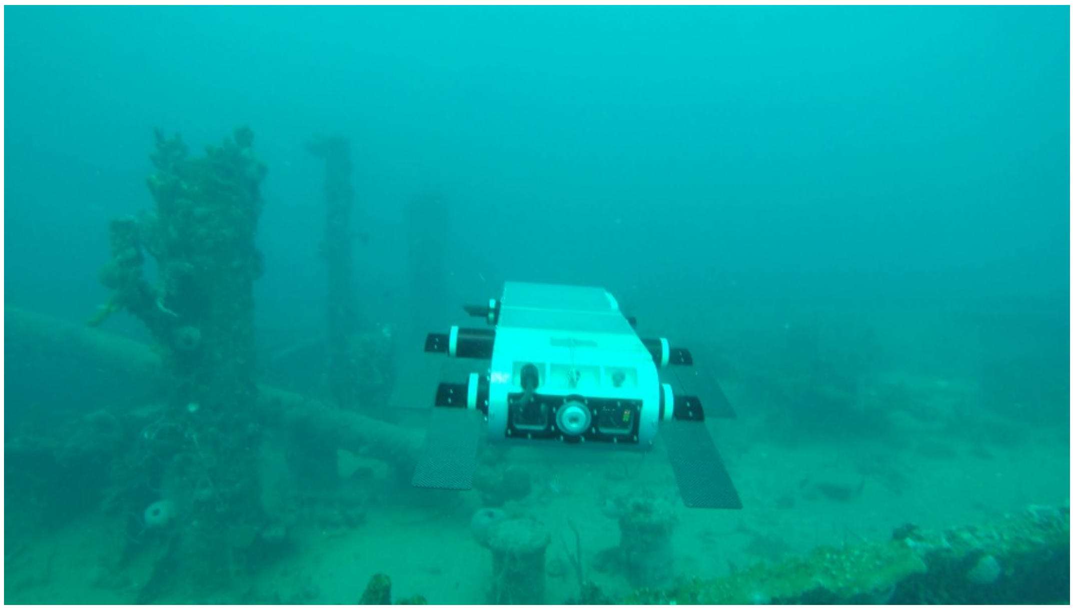
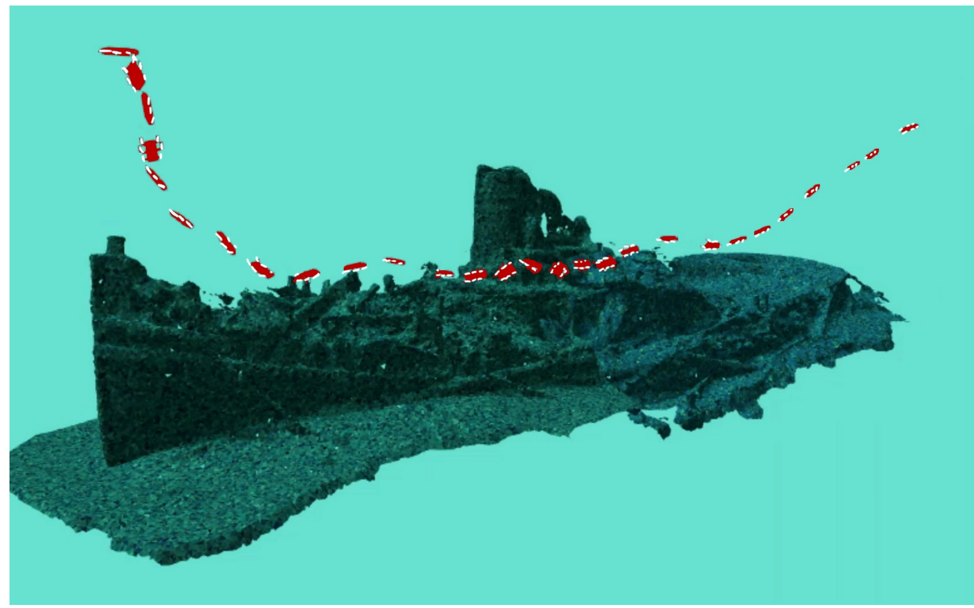
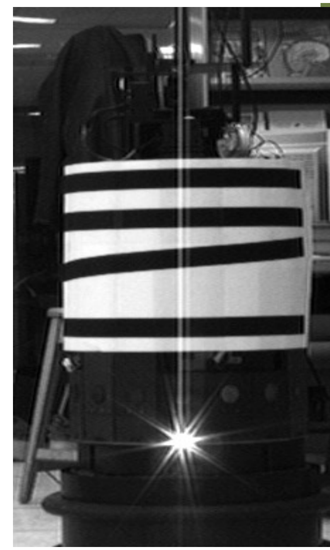


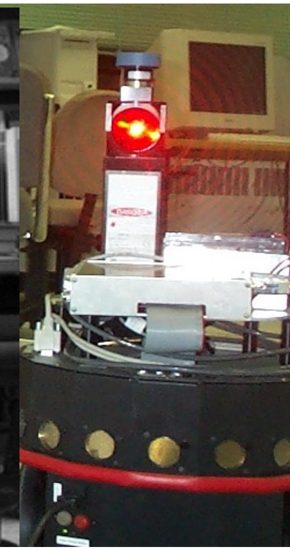
- **NSF Collaborative Research: NRI: INT:** Cooperative Underwater Structure Inspection and Mapping
- **Funding**: 2020-2024





Past Projects





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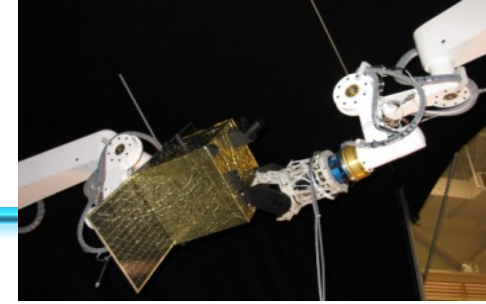
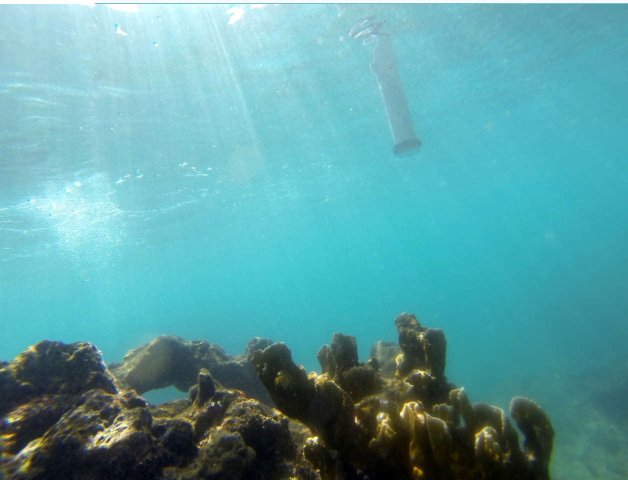


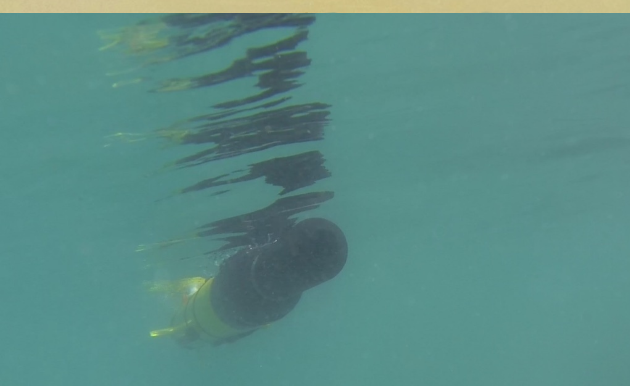
Aerial Robotics

Cooperative Localization

- Inferring relative pose
- Using vision only
- Bearing only data

Coral Reef Monitoring by Heterogeneous Robots

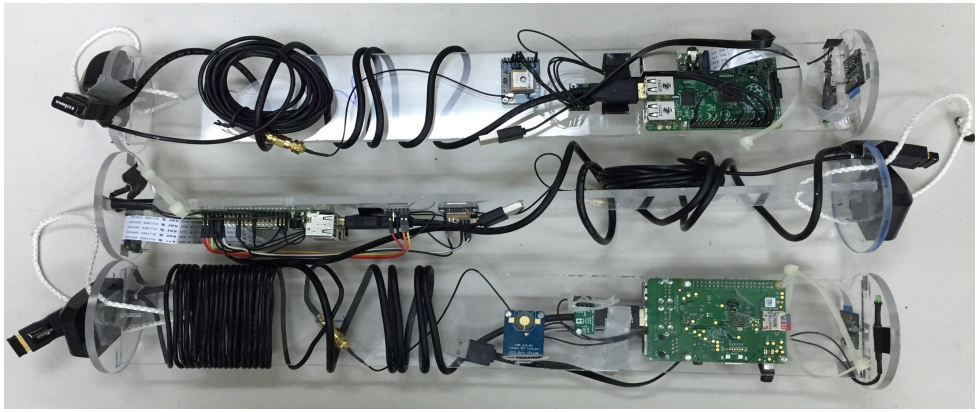




Marine Robotics

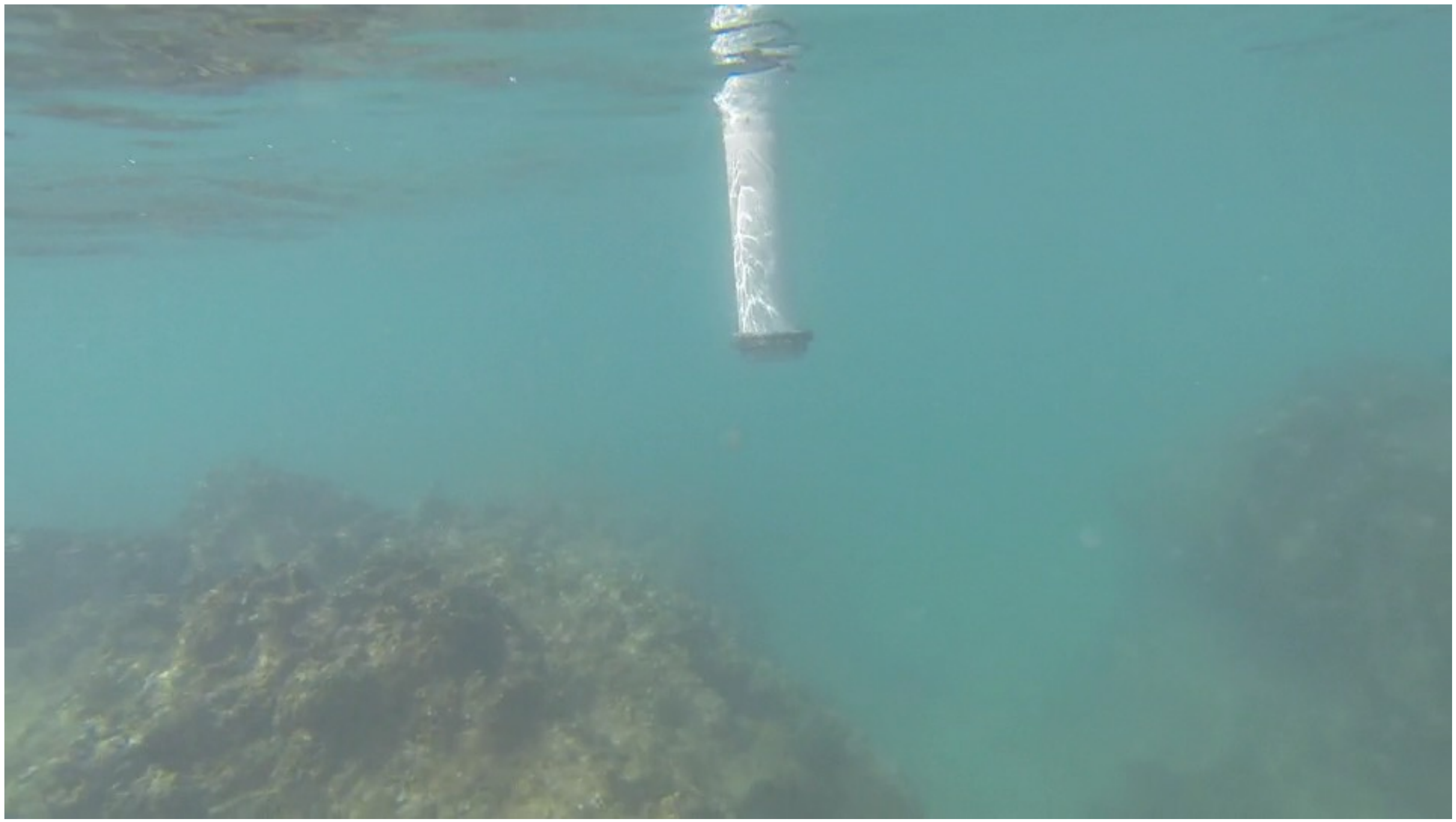
Capstone Project: Drift Nodes

- Measure Lagrangian current characteristics, marine life, salinity, turbidity, etc.
- Improve estimation accuracy



Marine Robotics: Drift Nodes

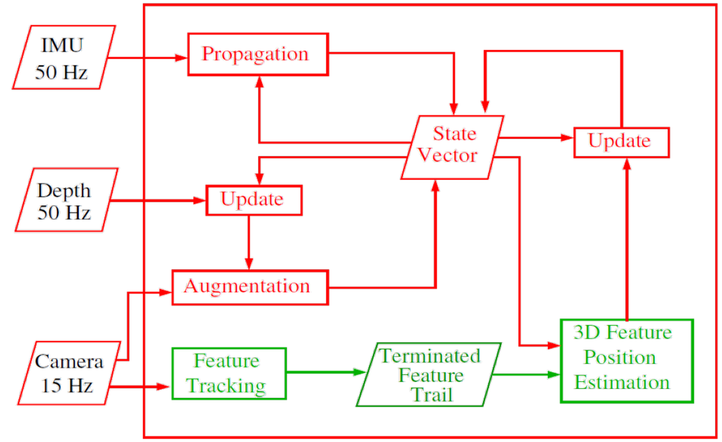
- Monitor, shallow coral reefs.
- Improve estimation accuracy



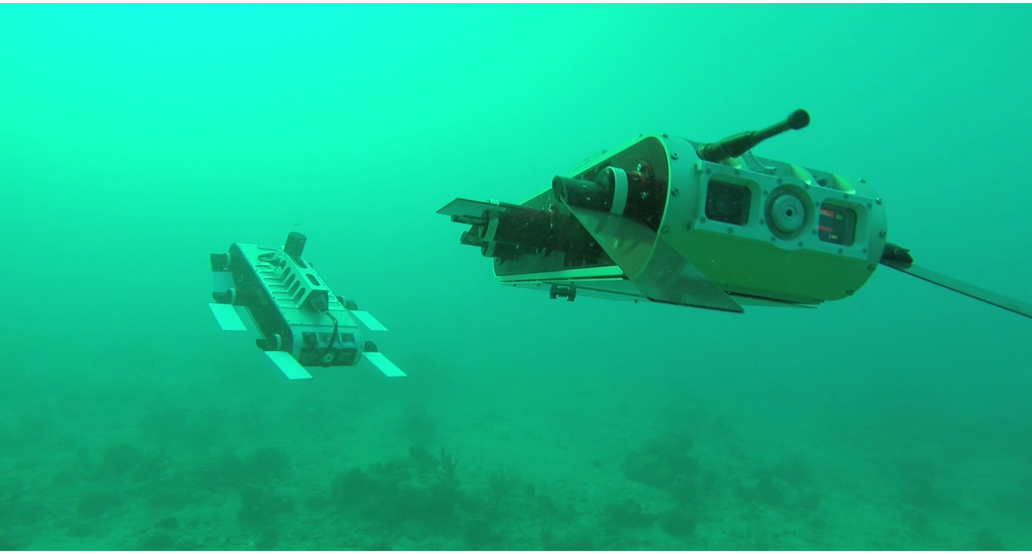
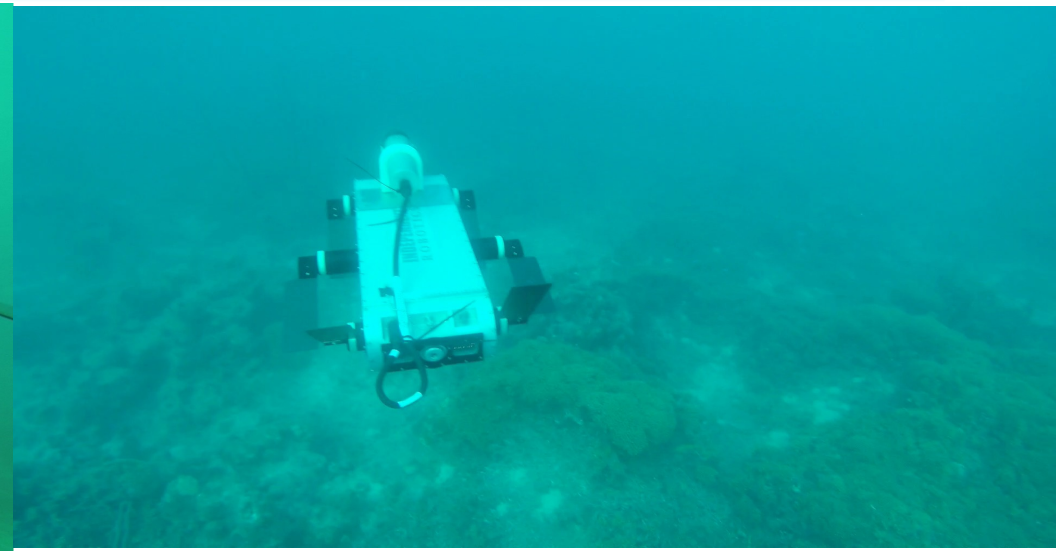
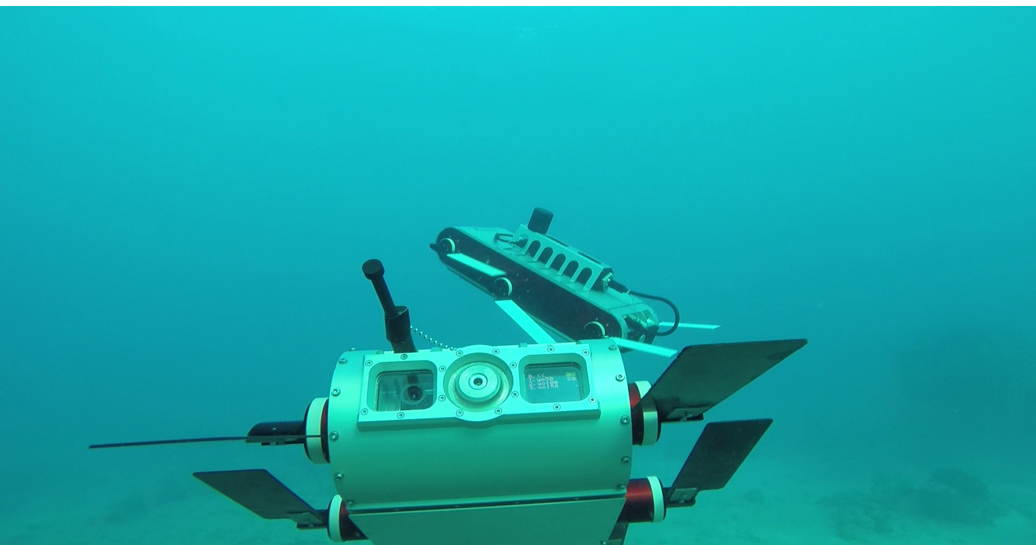
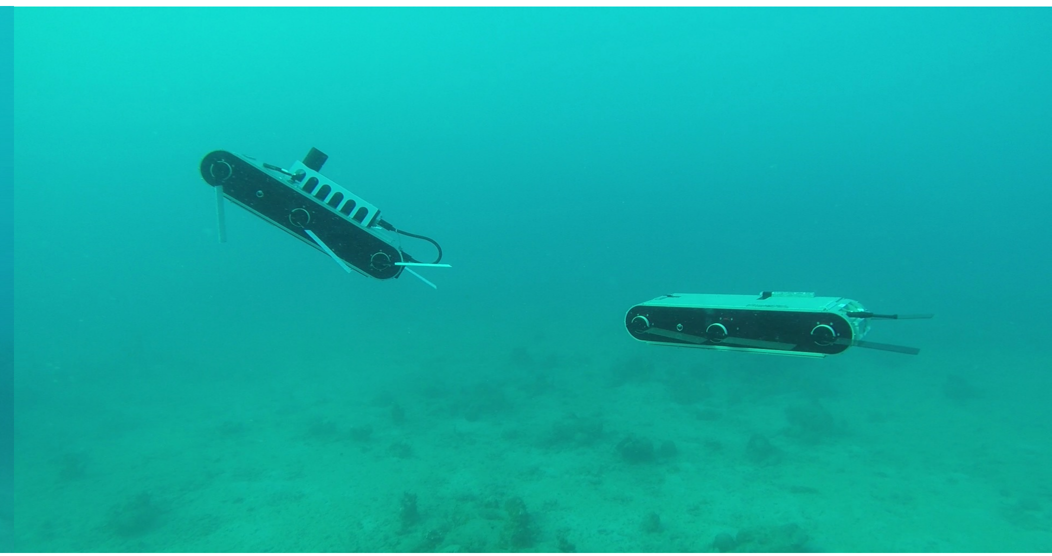
Marine Robotics

Underwater Situational Awareness

- Vision-INS State Estimation
- Path Planning
- Mapping

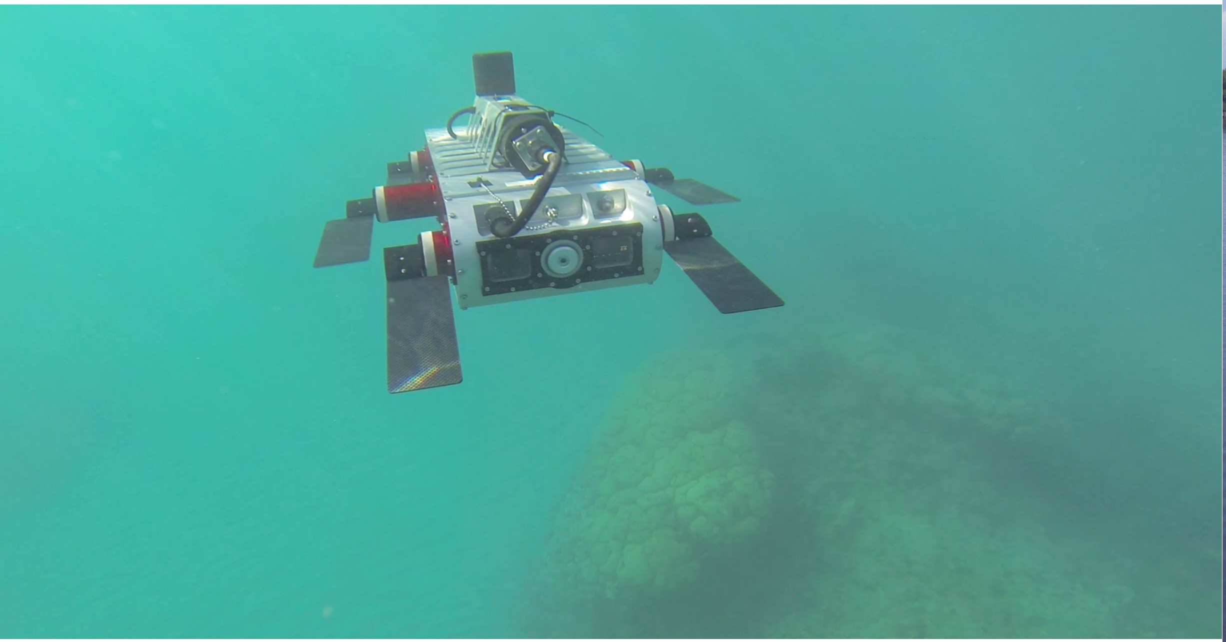


Marine Robotics

Vehicles

- Two Aqua with USBL



Vehicles

- Six ASVs

Vehicles

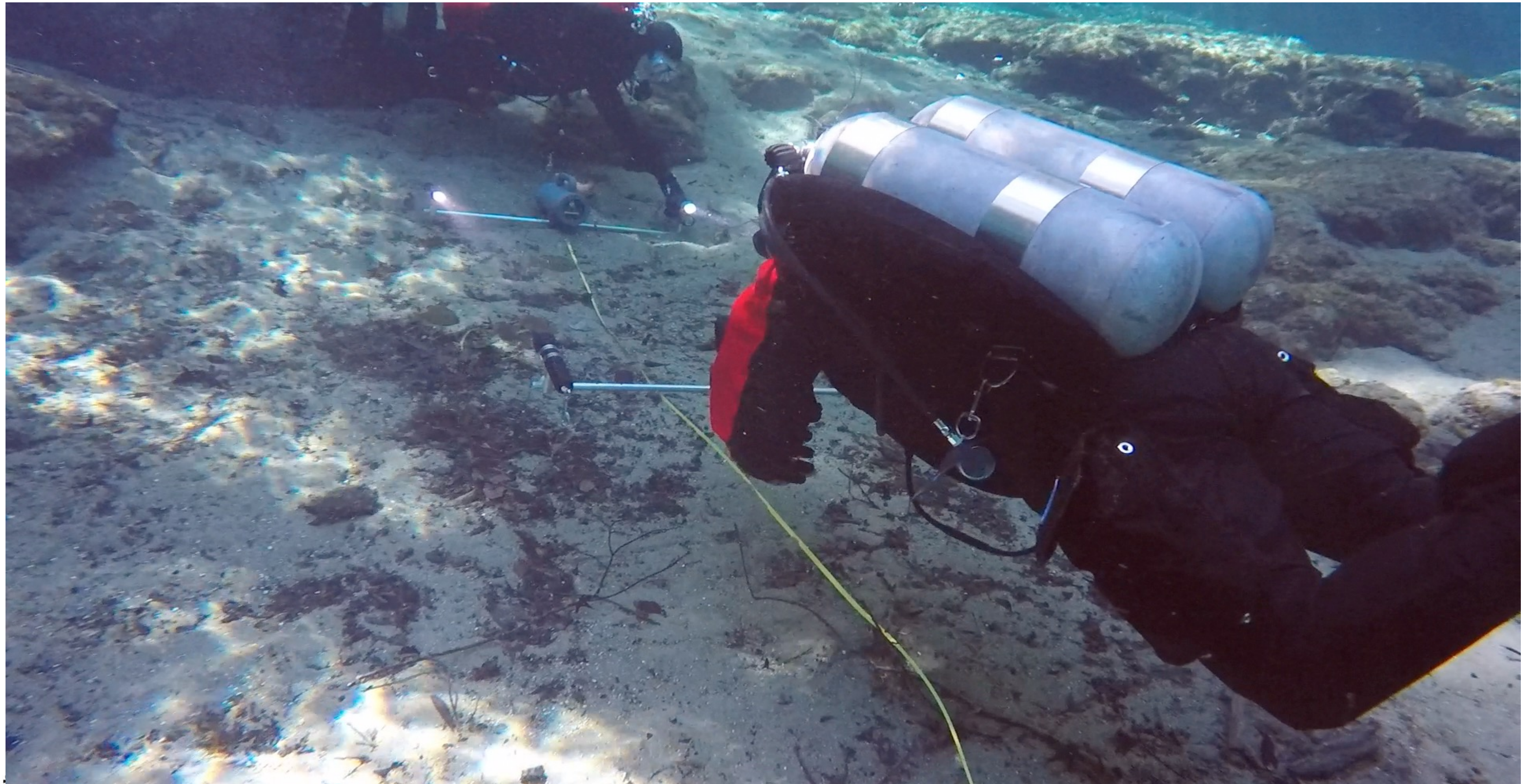
- Drones

Sensors

- Stereo Rig – 2017 (made at SC)

Sensors

- Cooperative Localization (made at SC)



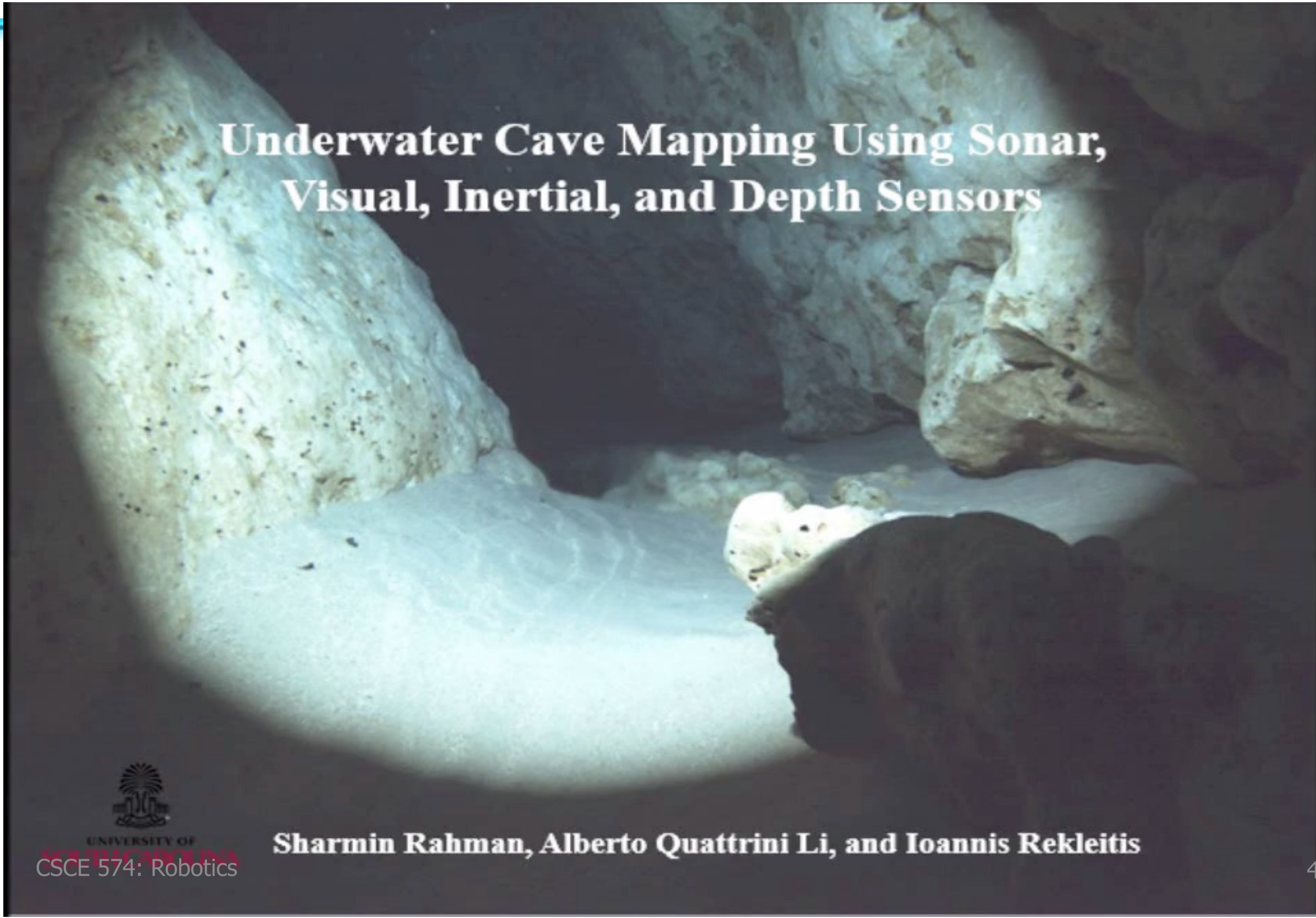
Shipwreck Mapping

Shipwreck Mapping

Robot's Eye View

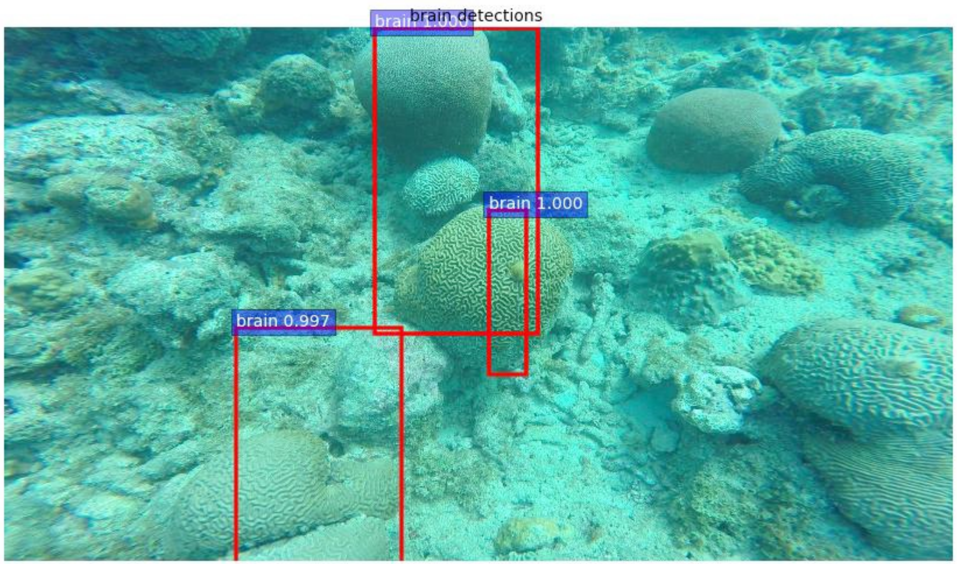
Underwater Cave Mapping

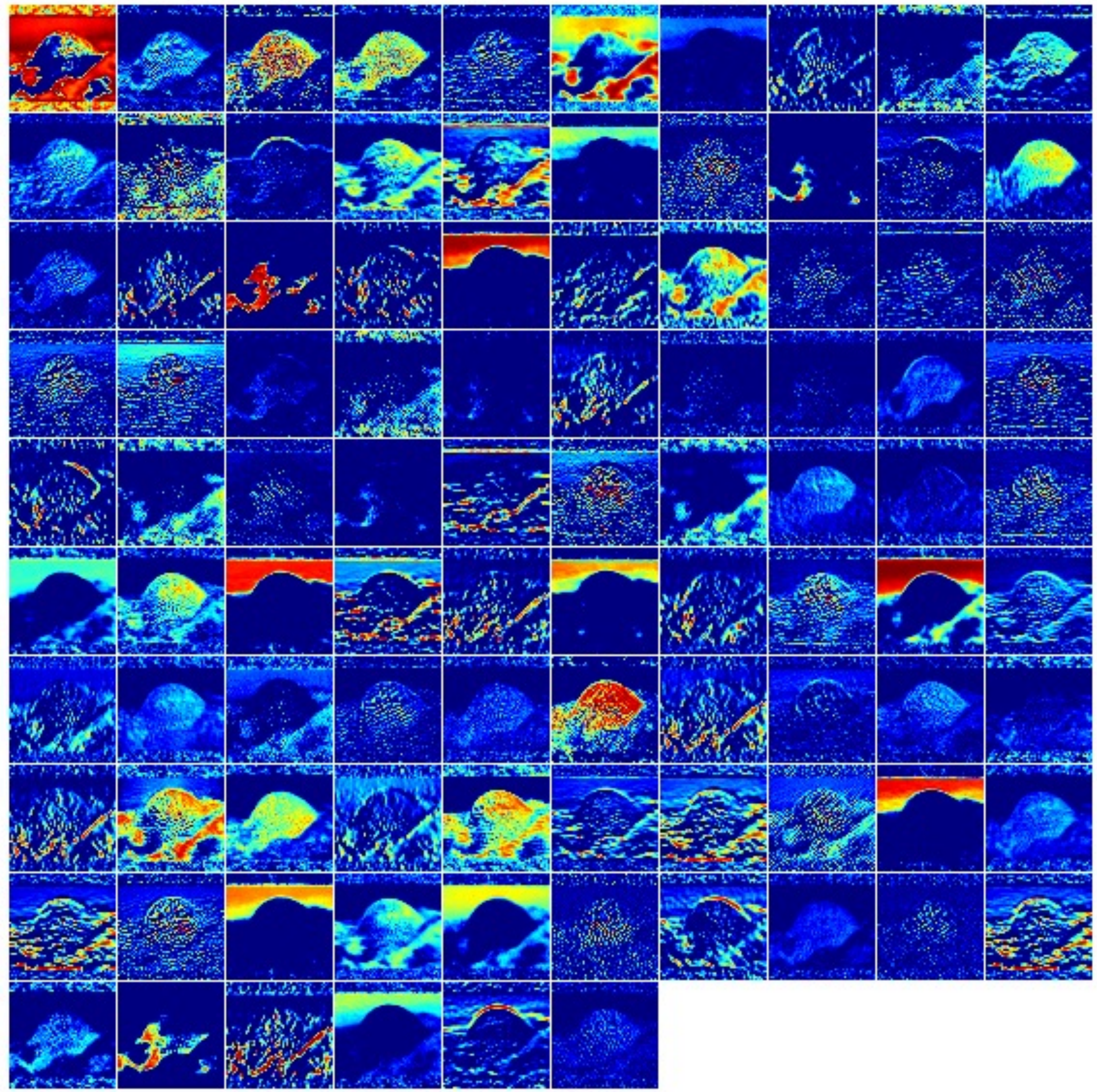
Underwater Cave Mapping



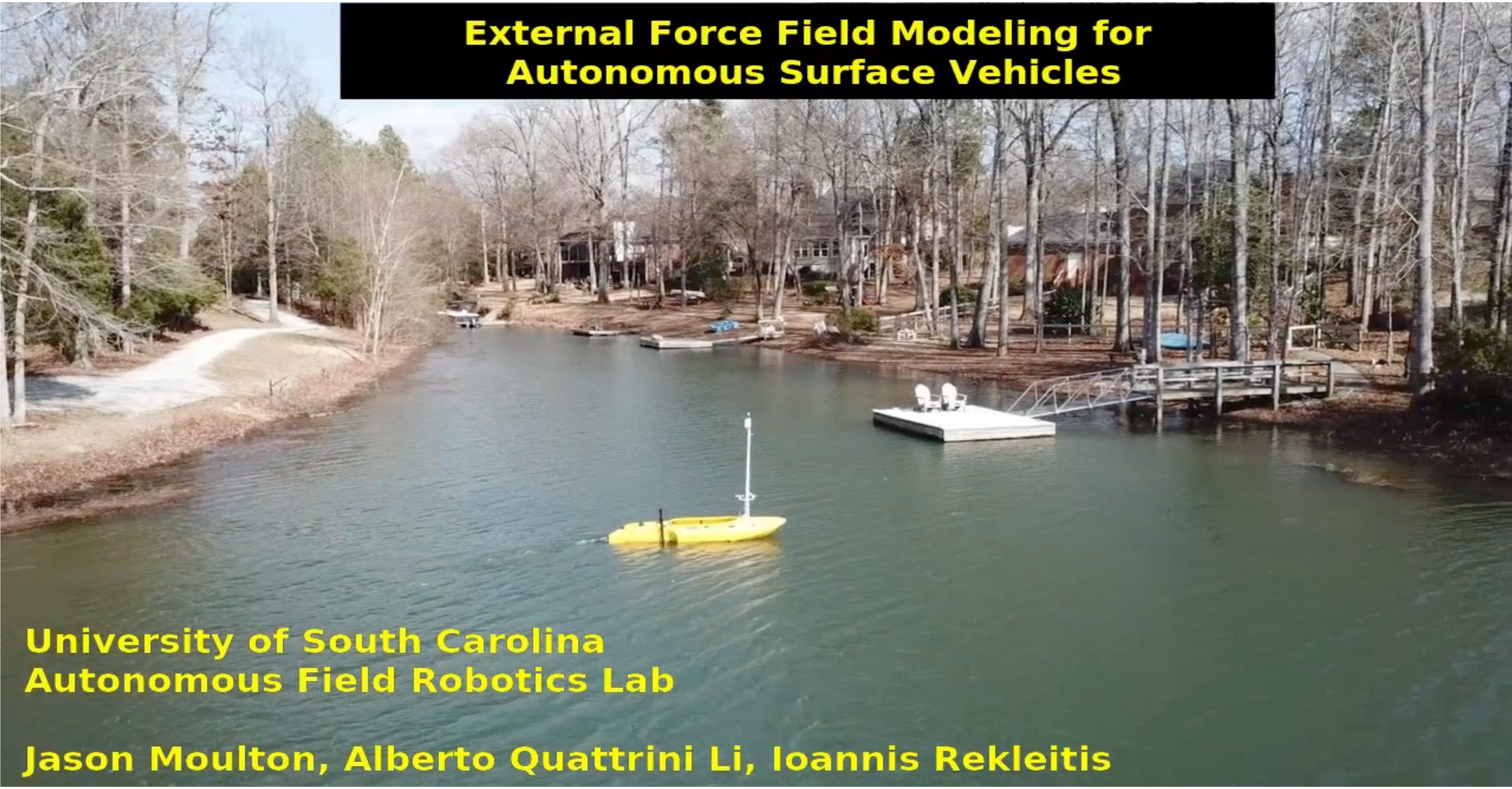
Shallow Coral Classification using Deep Learning

- Using a CNN

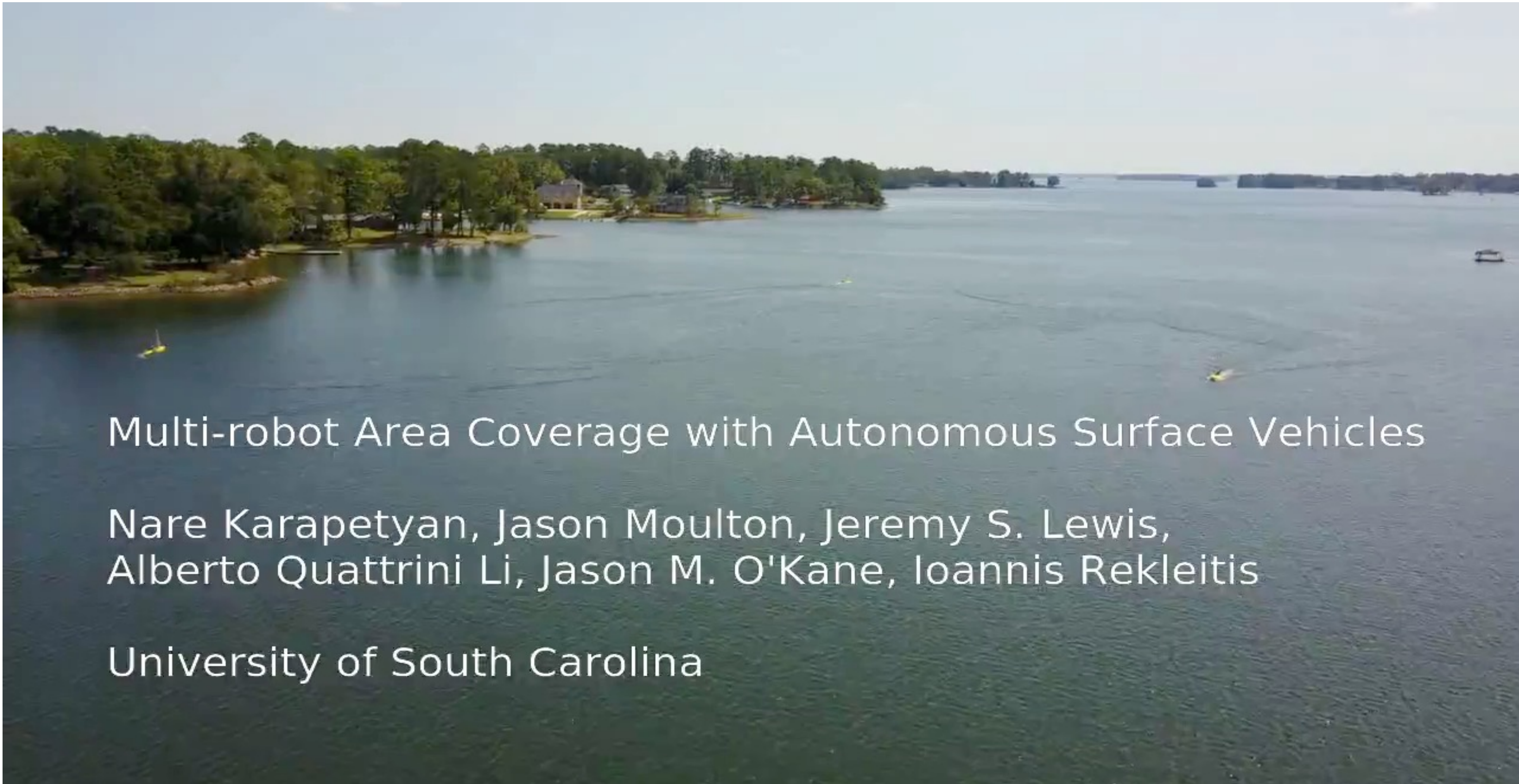




ASV Modeling of Adverse Conditions

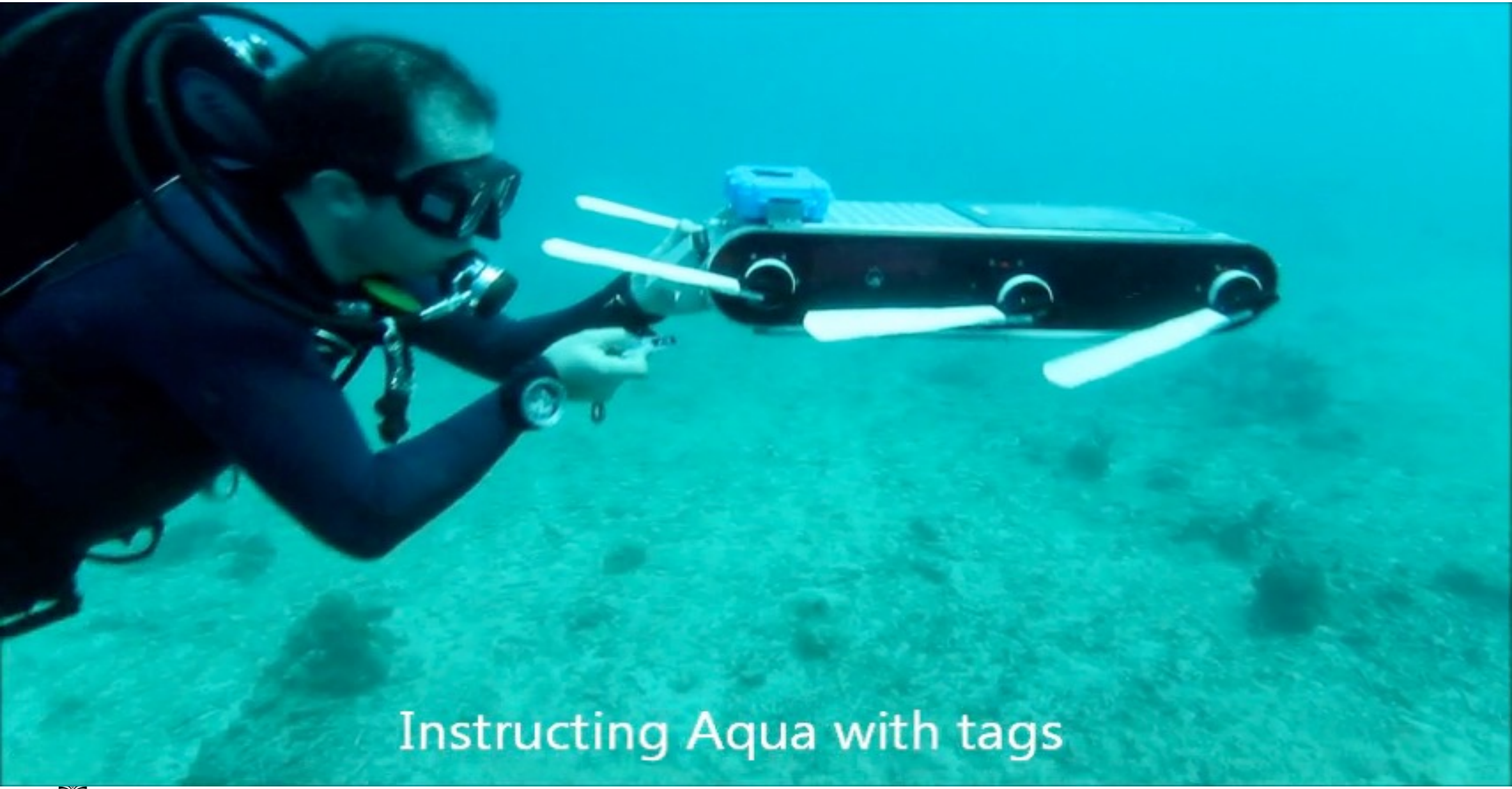


Single/Multi Robot Coverage
Dubins Vehicle kinematics

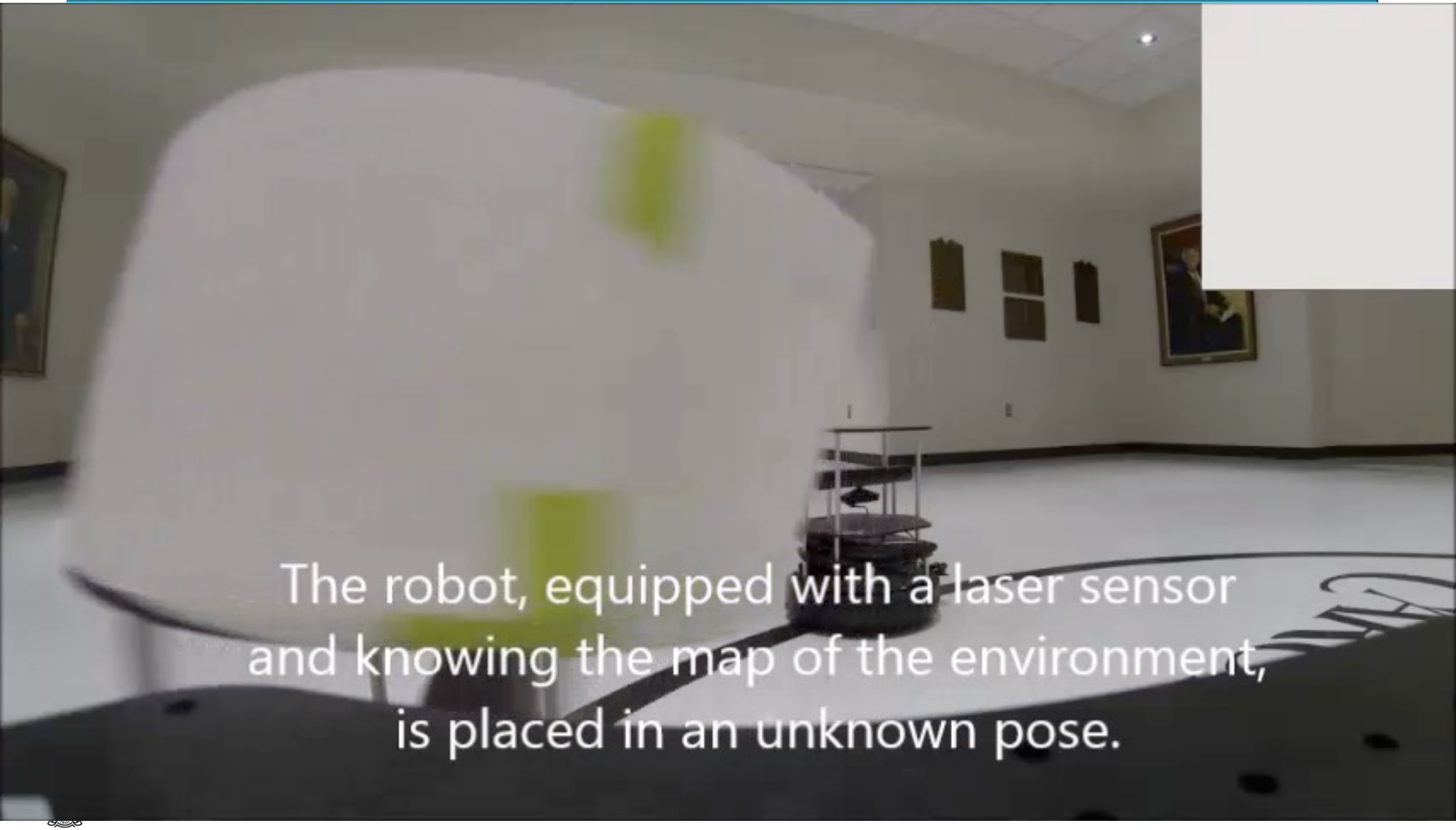


Marine Robotics:

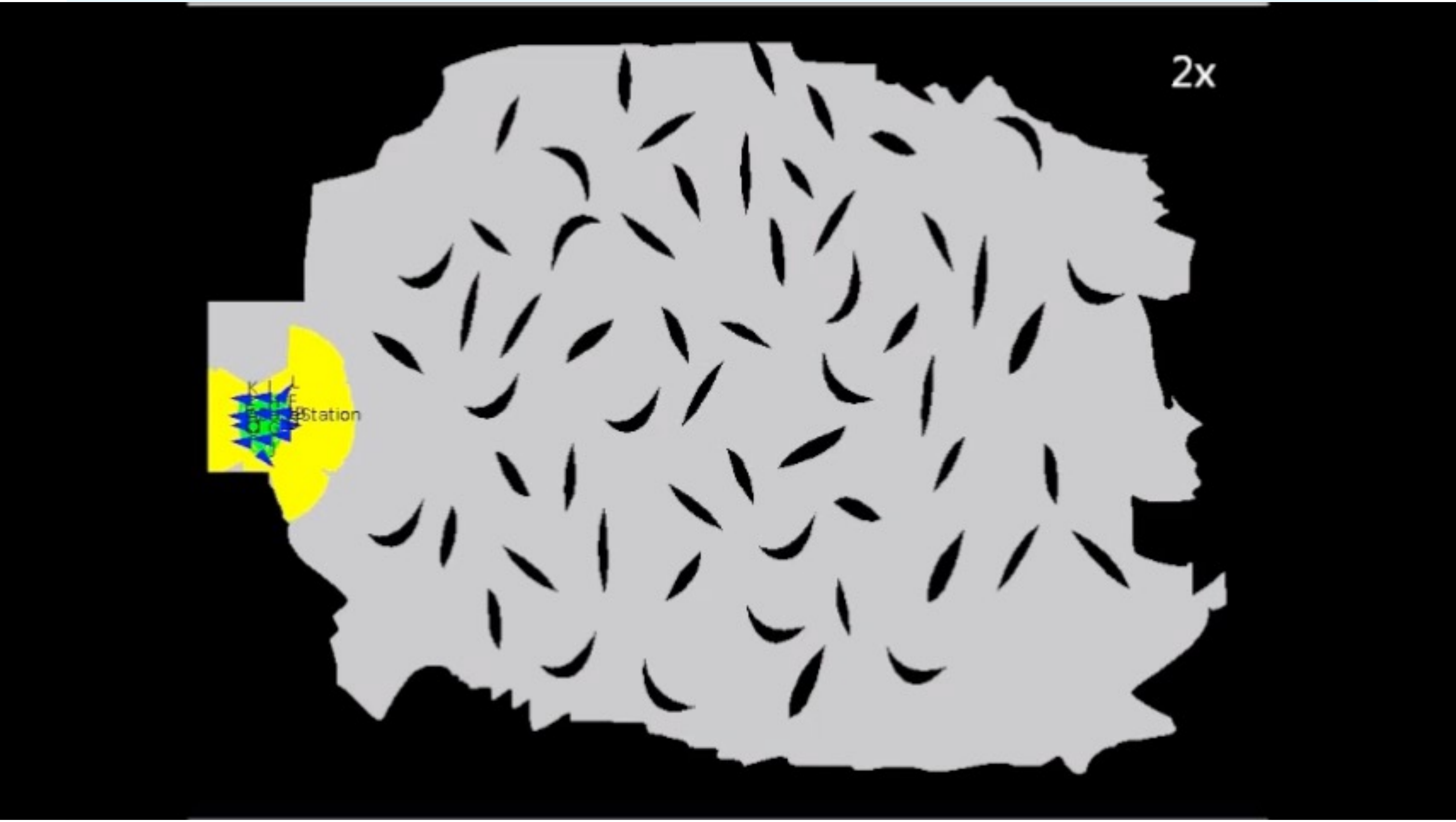
HRI with limited bandwidth



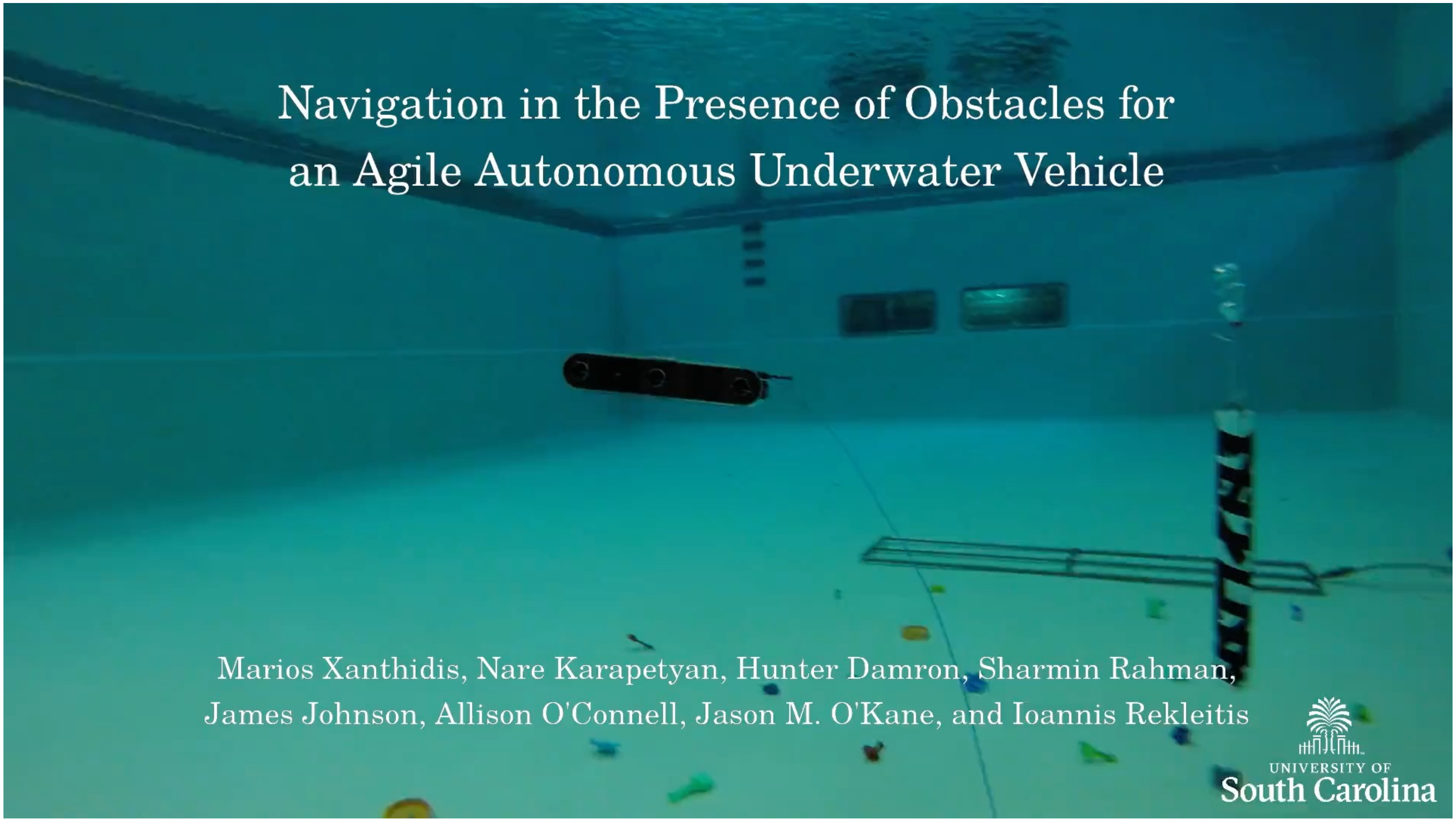
Indoor: Localization with dynamic obstacles



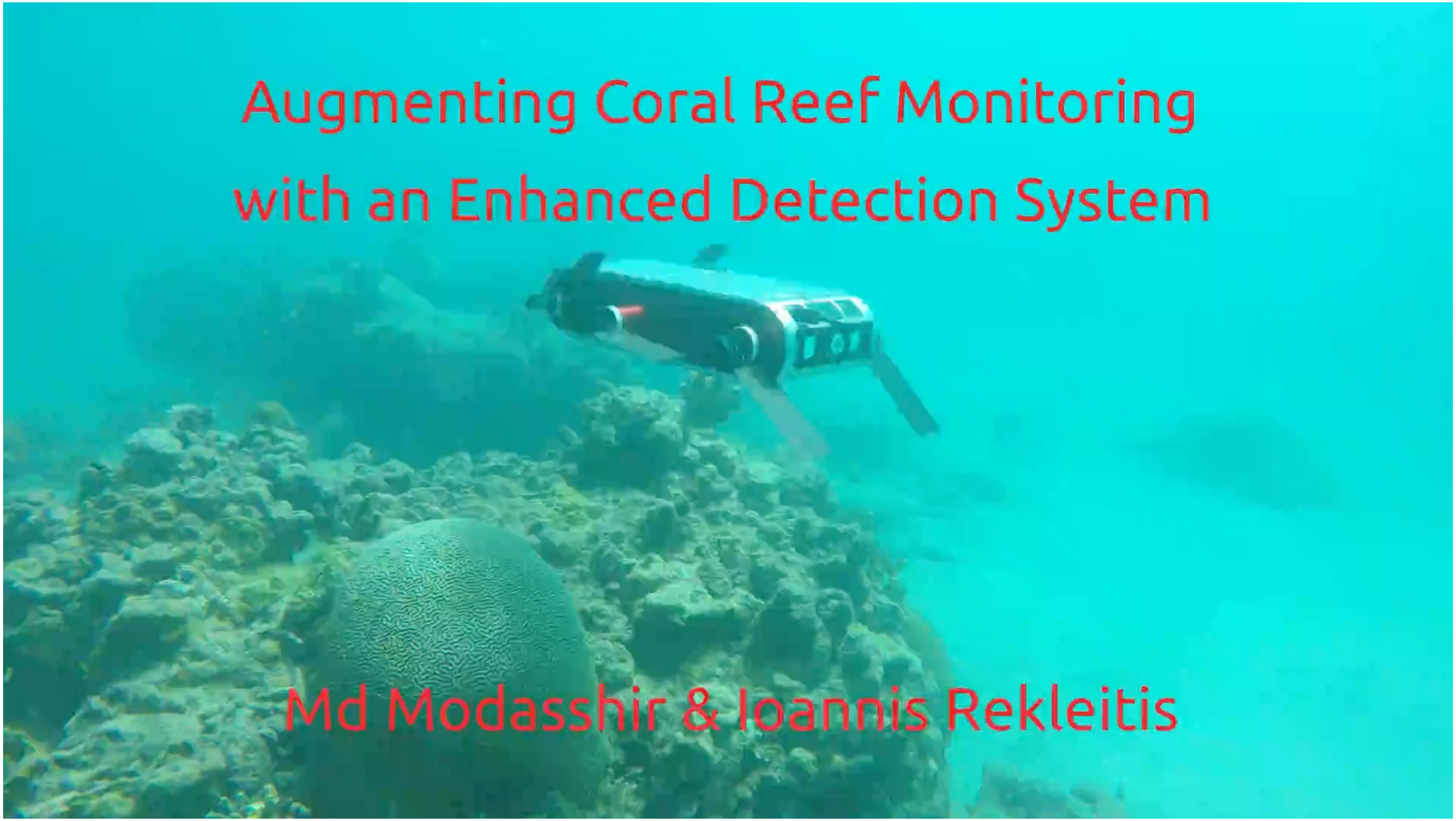
Indoor: Communication Constrained Exploration



Underwater Navigation



Coral Reef Monitoring



Riverine Coverage