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

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

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

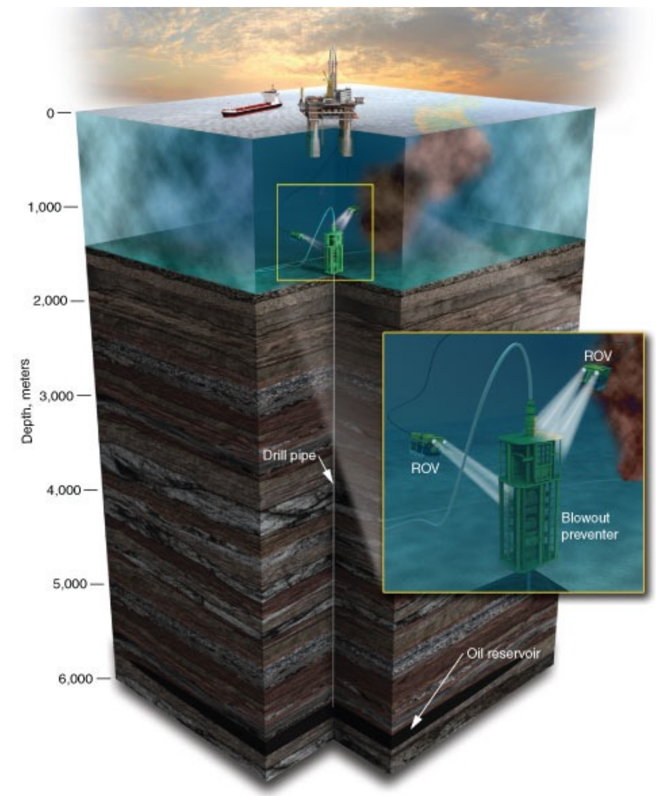
QUADH2O
MULTIROTOR

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

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



Present Everywhere

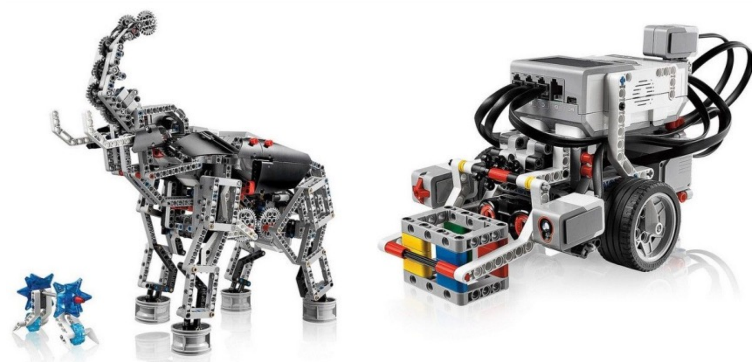
- At home
- On the road
- In the sky (drones)
- In the fields
  (agricultural robotics)
- In resource utilization
  (ROV in the oil industry)
- **Along power lines**
- In Hospitals
- Education
- In Factories
- In Warehouses
- In Space

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/Care facilities**
- Education
- In Factories
- In Warehouses
- In Space

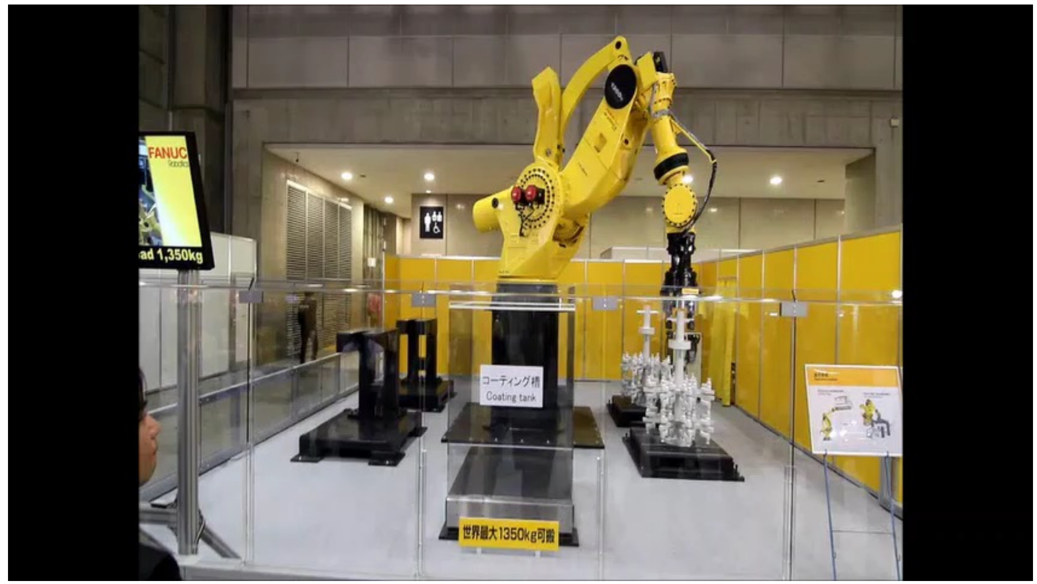
Present Everywhere

- 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



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



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

Amazon bought Kiva for $775M

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**

Robotic technology becomes affordable

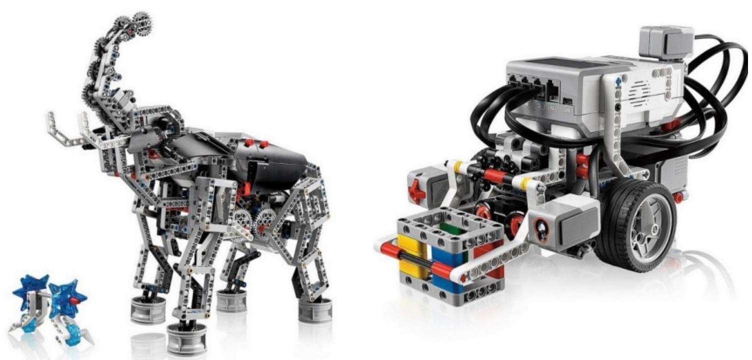
TurtleBot 2

AR.DRONE

Kinect

IMU

Raspberry Pi

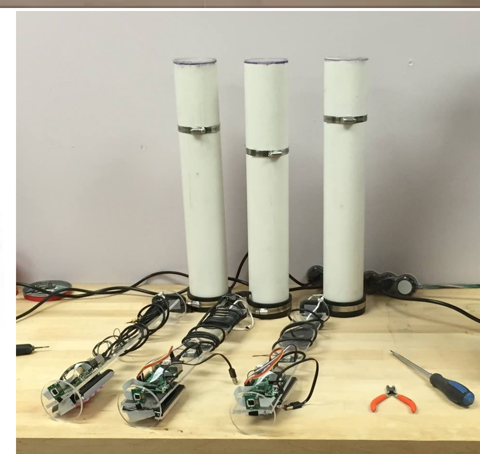


Lego Mindstorm

GPS

Robotics at USC

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



Autonomous Field Robotics Lab

Autonomous Field Robotics Lab

Philosophy

Develop algorithms for robotic applications

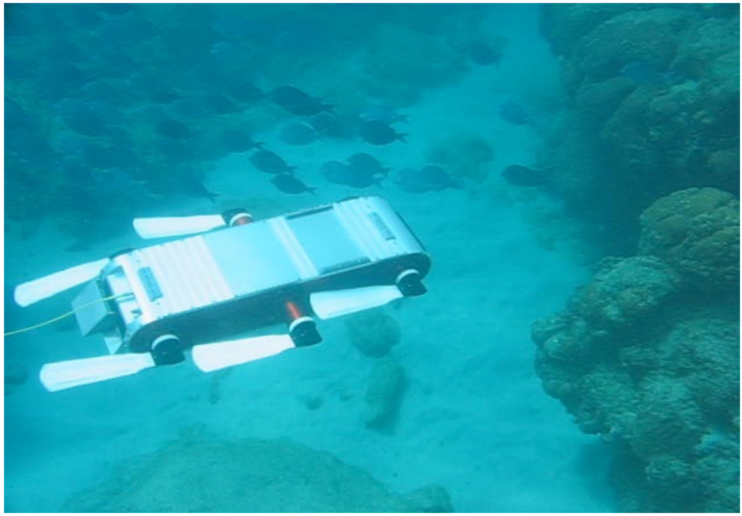
Deploy algorithms on fielded robots

(Aerial, ground, surface, and/or underwater)

Evaluate performance of the deployed robots

Recent Funding:

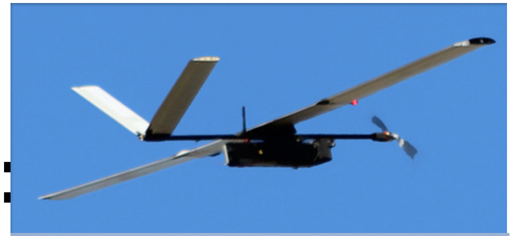
- **NSF CRI II-New**: Acquisition of a Heterogeneous Team of Field Robots for Coastal Environments
- **PI: I. Rekleitis.**
- CoPIs: J. Beer, J. O'Kane



Several **Surface Vehicles**

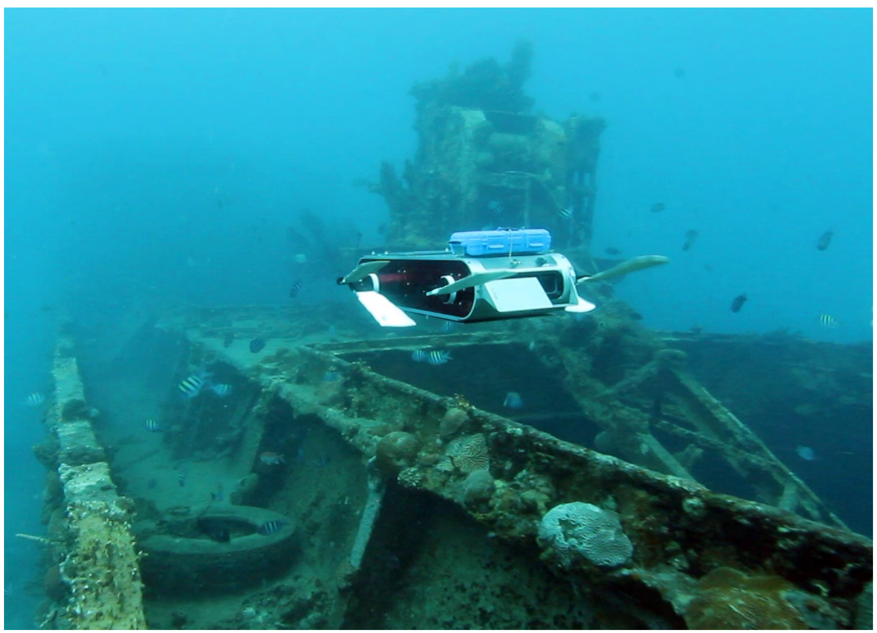
2 **Aqua** u/w vehicles

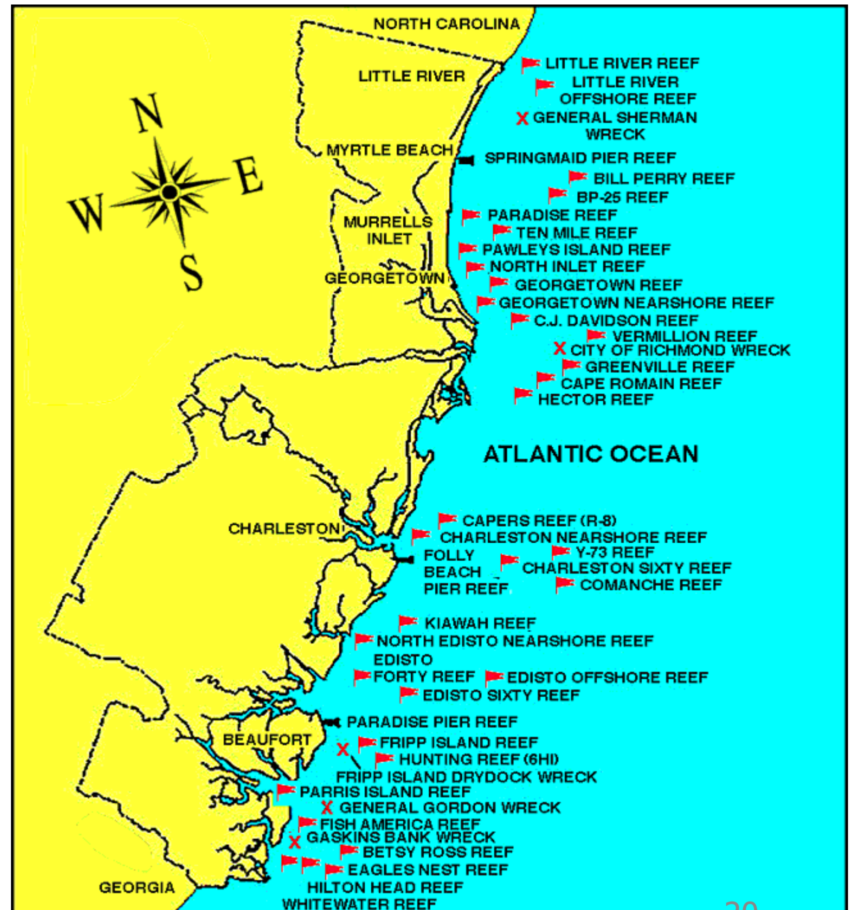
Aerial Vehicles:
2 fixed wings
2 quadrotor



Recent Funding:

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



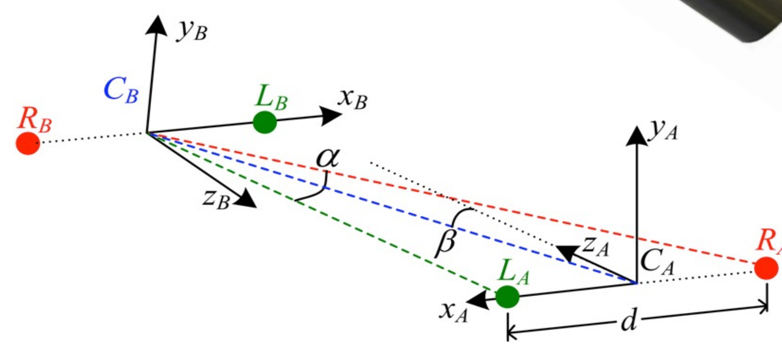


Recent Funding:

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

SONAR-Vision Fusion

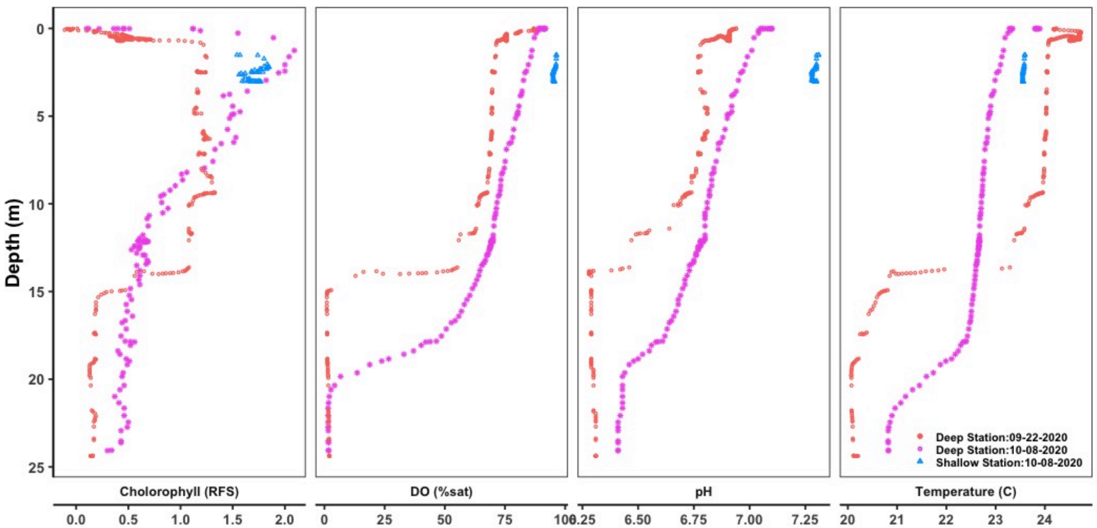
Stereo Based 3D Reconstruction



Cooperative Localization

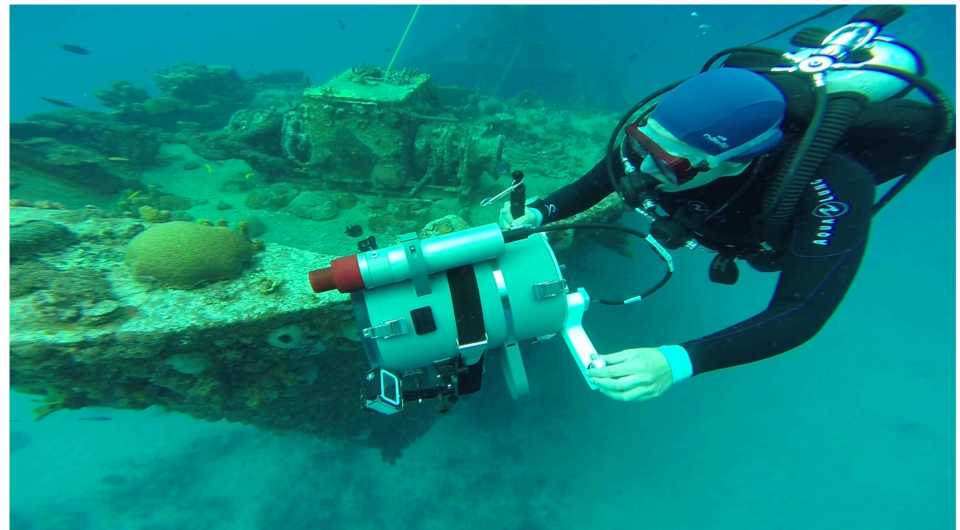
Recent Funding:

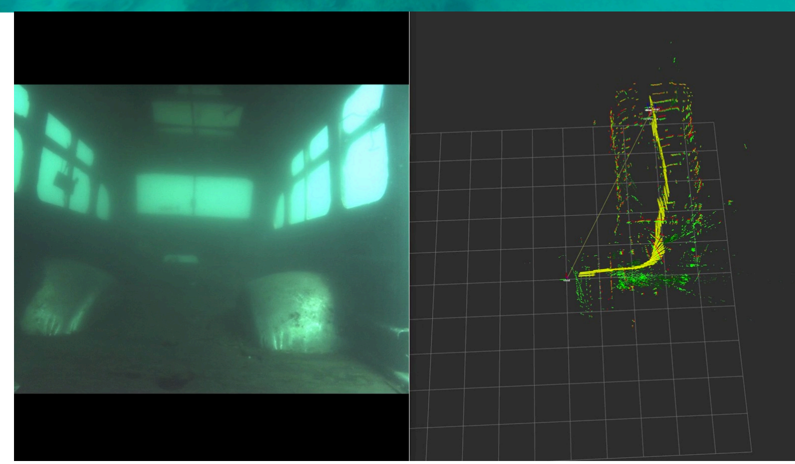
- **NSF RII Track-2 FEC:** Computational methods and autonomous robotics systems for modeling and predicting harmful cyanobacterial blooms.
- **Funding**: 2019-2023



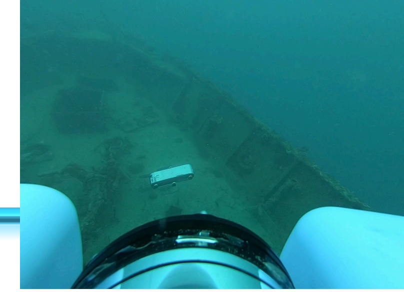
Recent Funding:

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

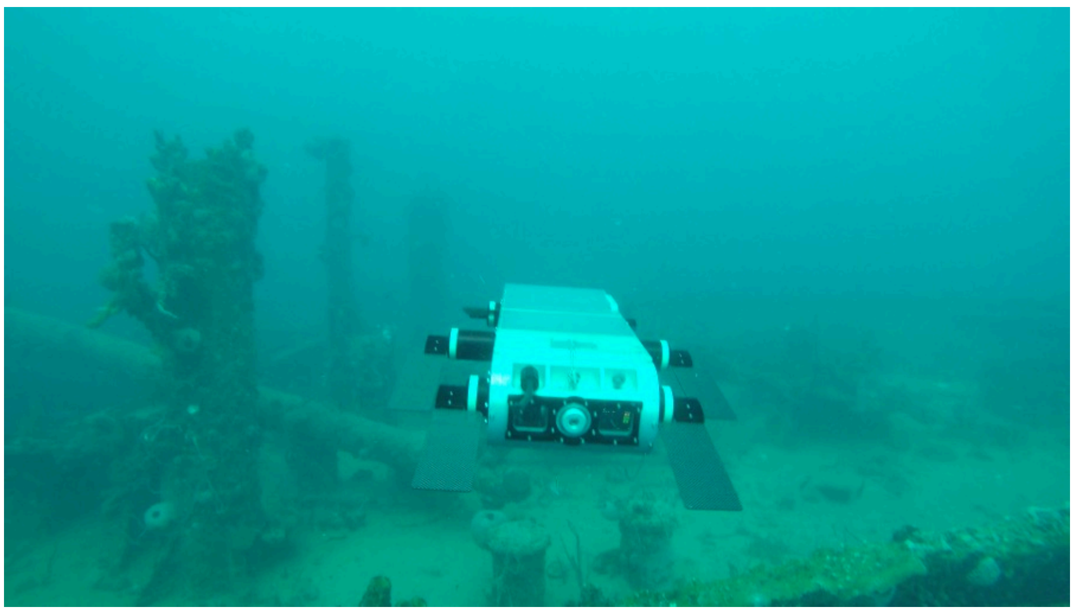


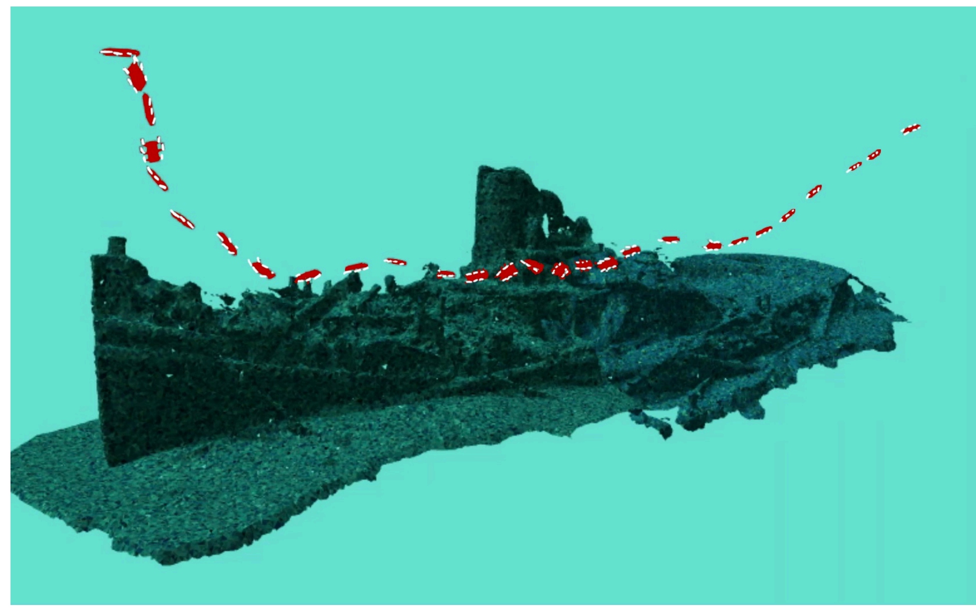


Recent Funding:

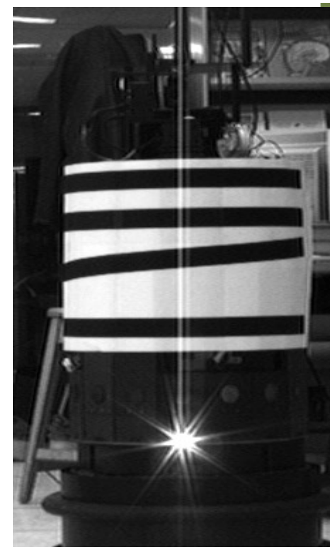


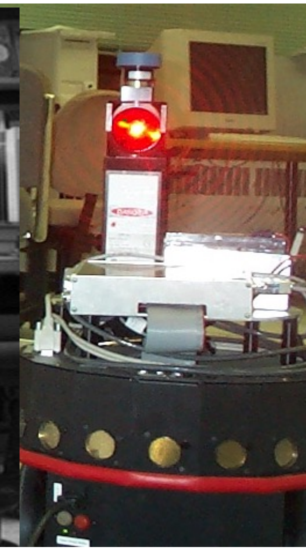
- **NSF Collaborative Research: NRI: INT:** Cooperative Underwater Structure Inspection and Mapping
- **Funding**: 2020-2024



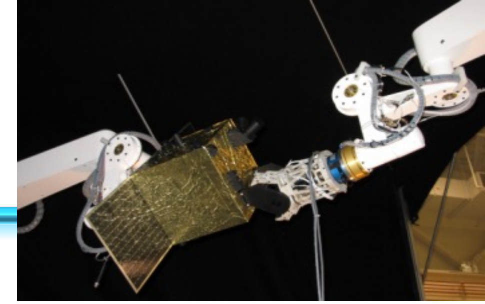


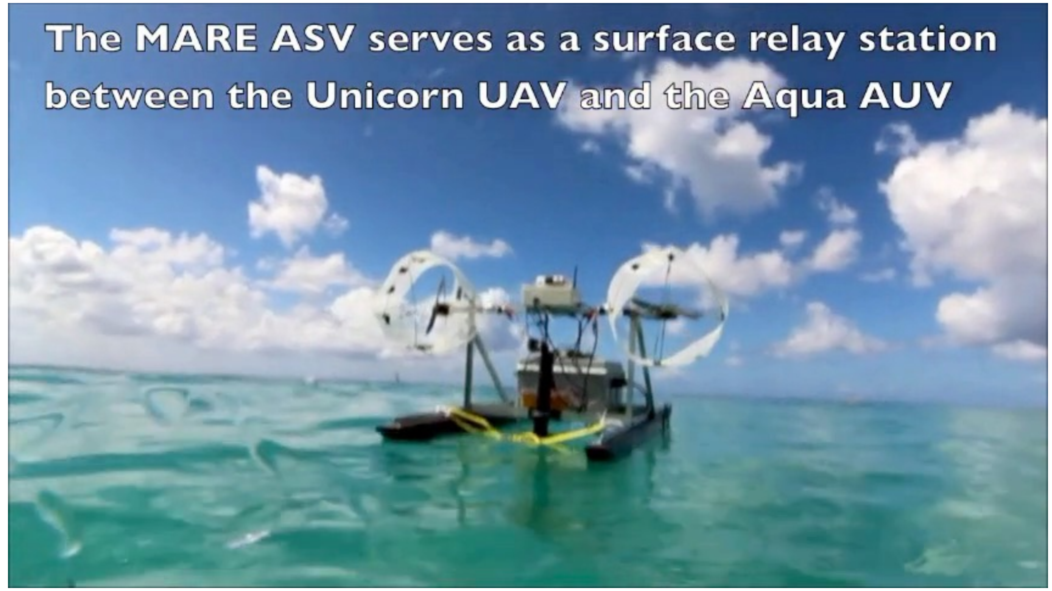
Past Projects





Past Projects



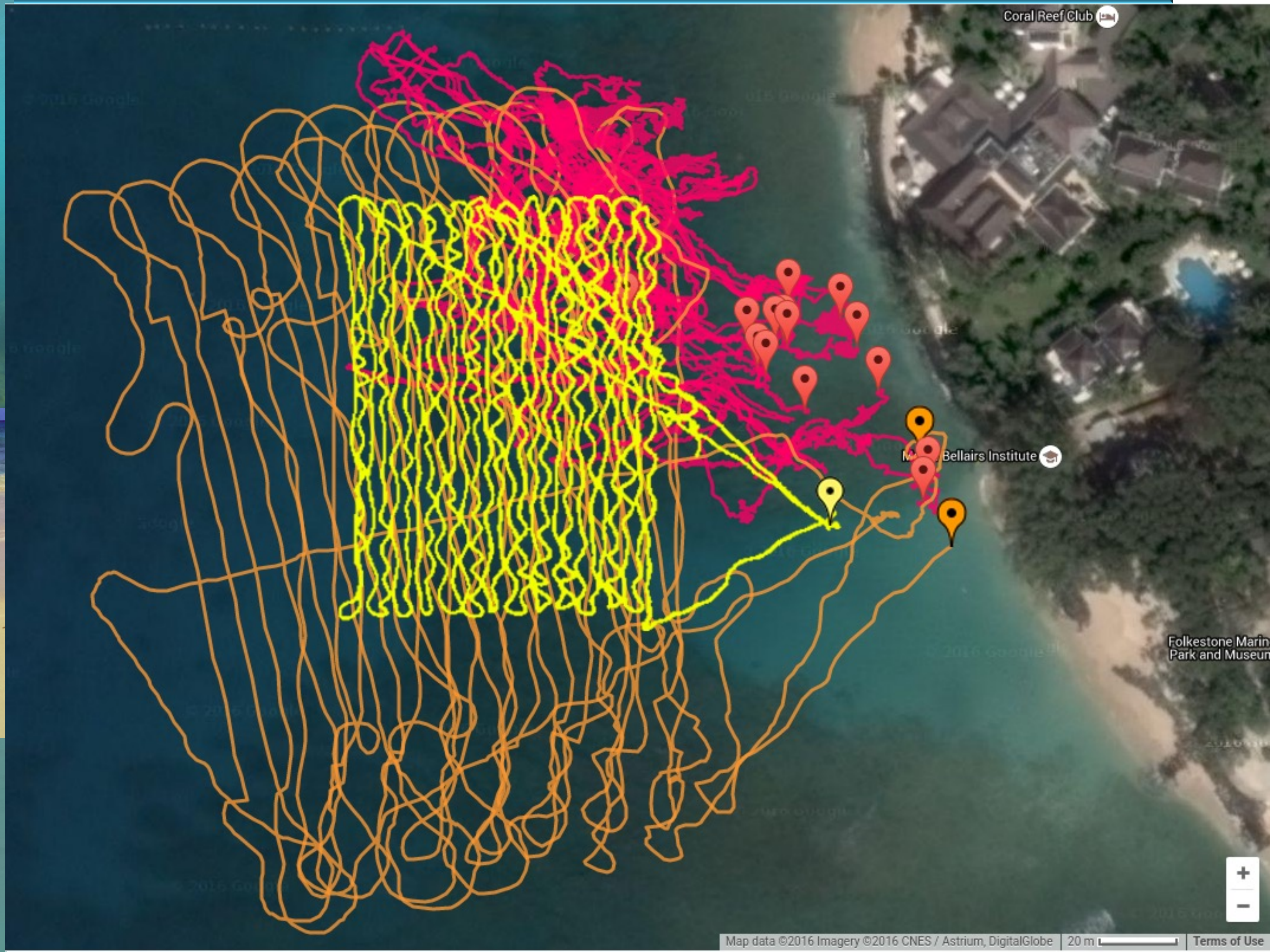


Aerial Robotics

Cooperative Localization

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

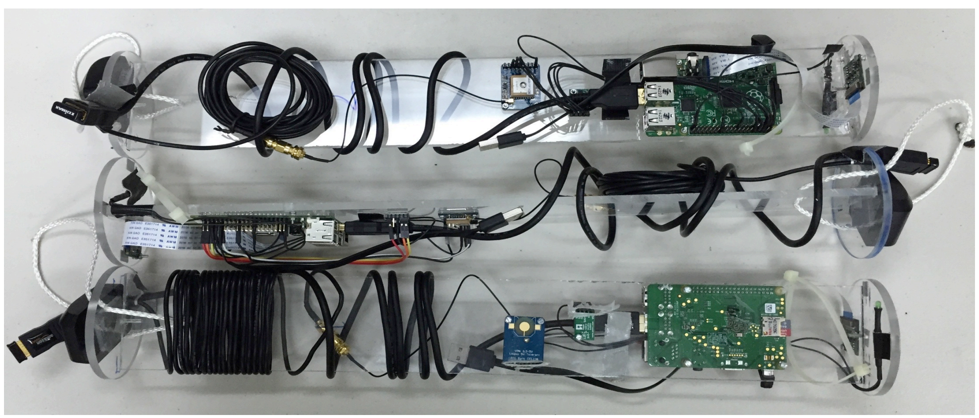
Coral Reef Monitoring by Heterogeneous Robots



Marine Robotics

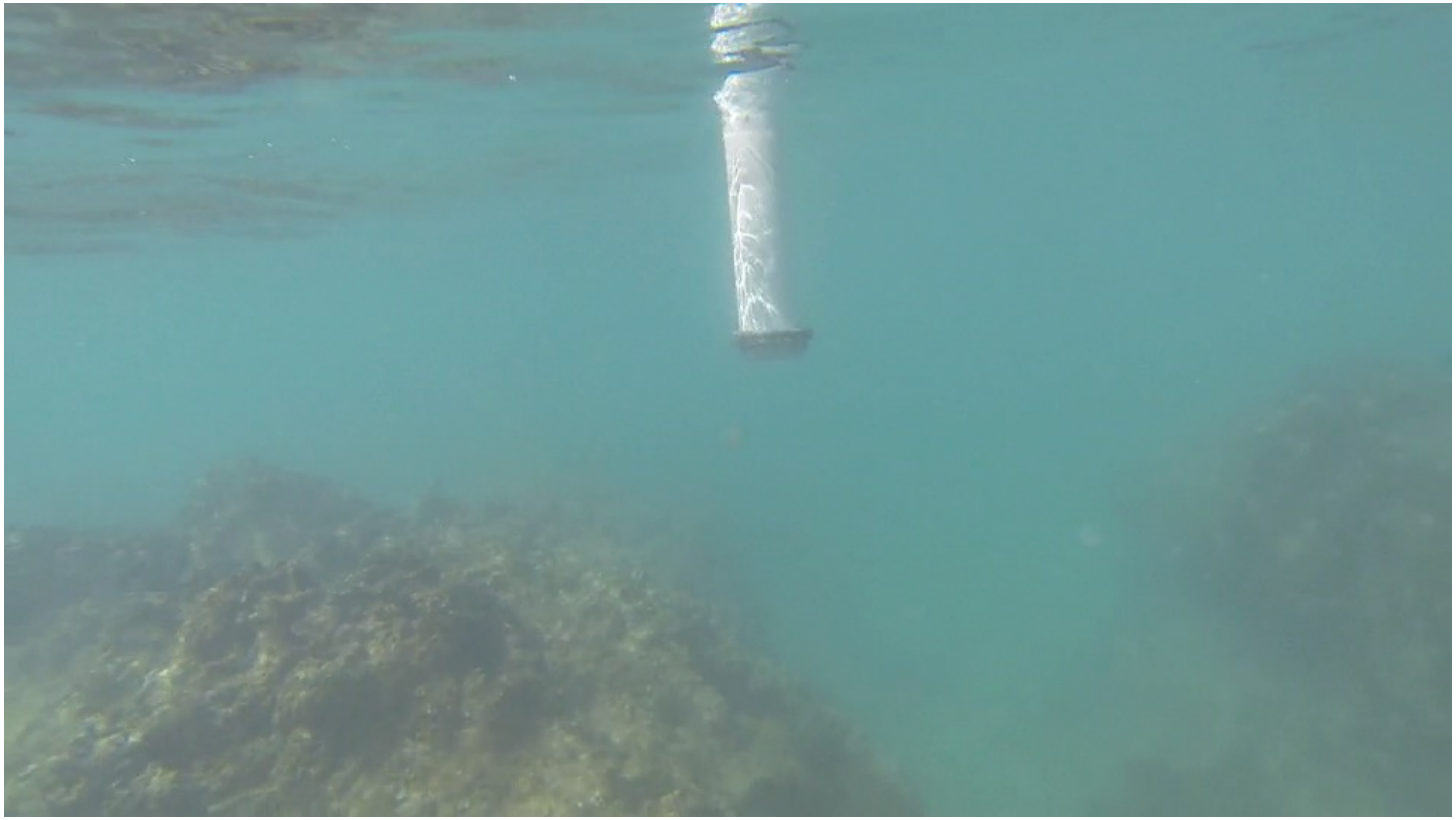
Capstone Project: Drift Nodes

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



Marine Robotics: Drift Nodes

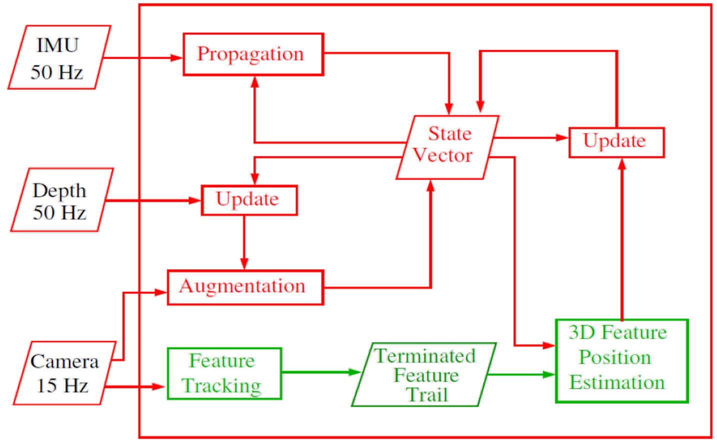
- Monitor, shallow coral reefs.
- Improve estimation accuracy



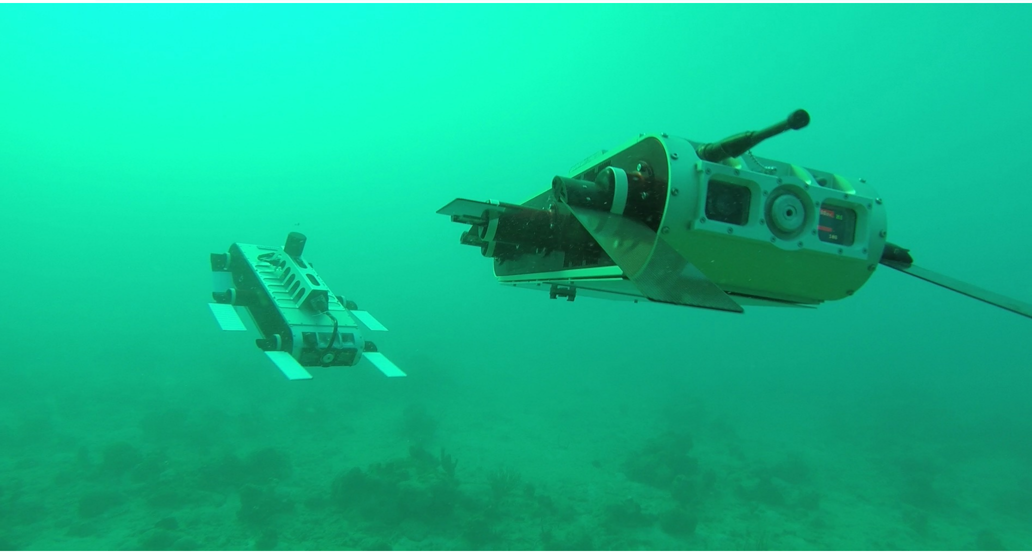
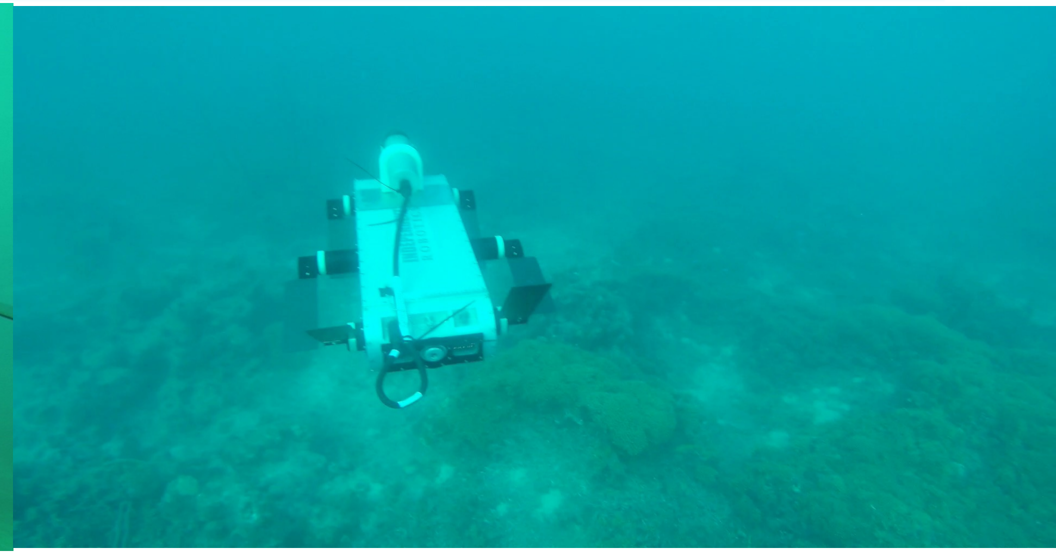
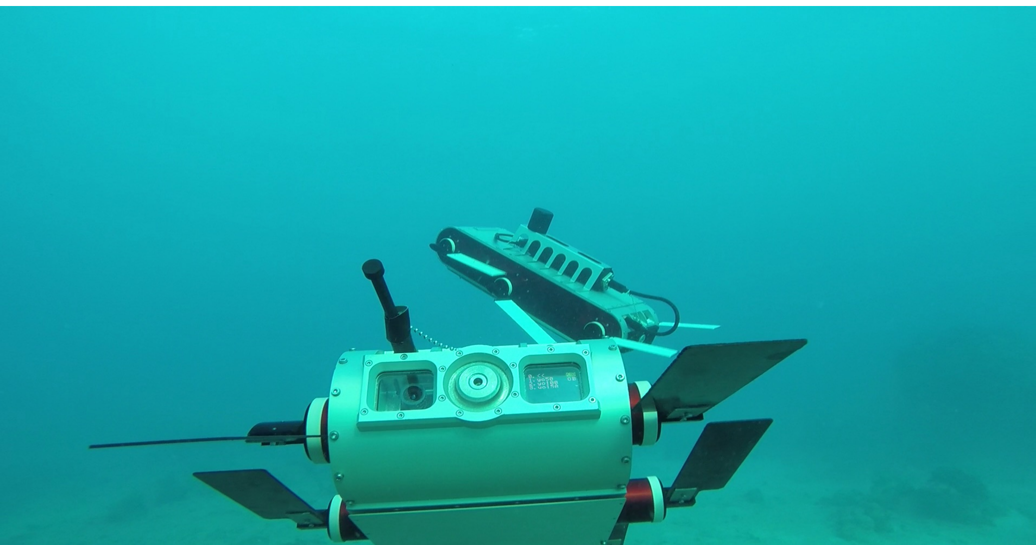
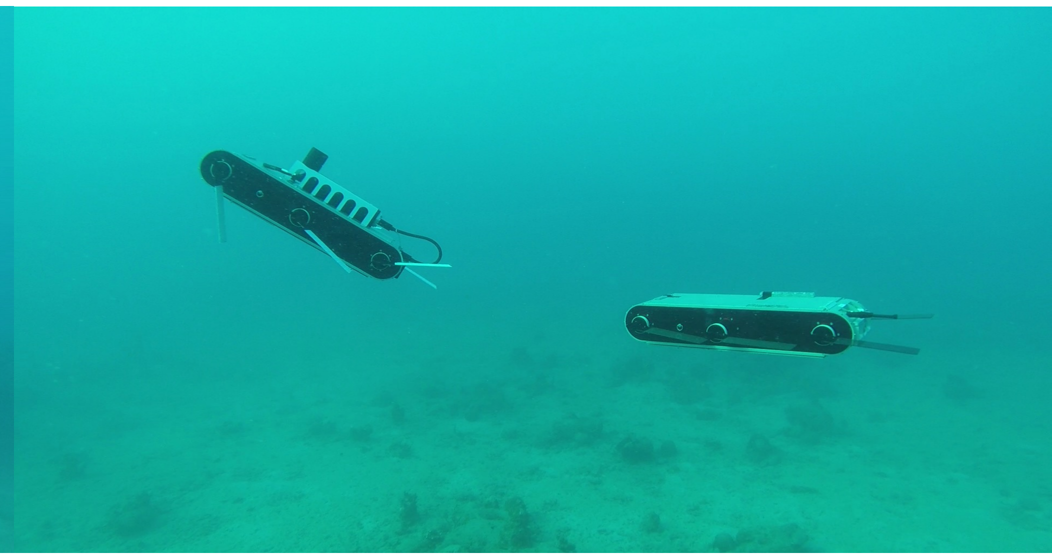
Marine Robotics

Underwater Situational Awareness

- Vision-INS State Estimation
- Path Planning
- Mapping

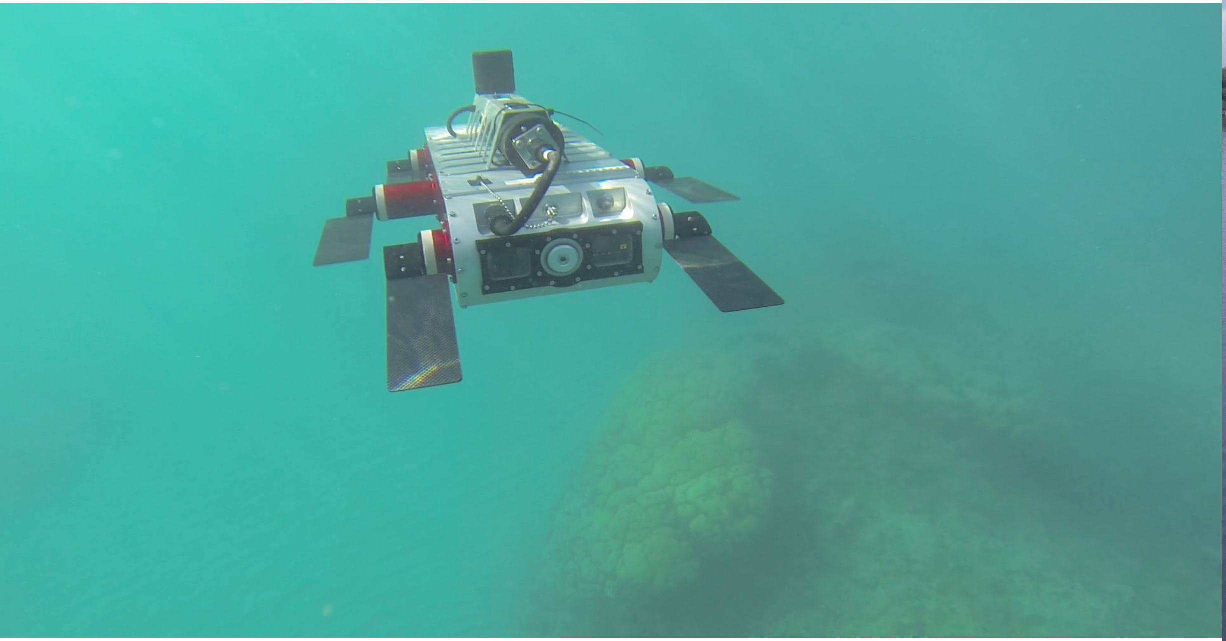


Marine Robotics

Vehicles

- Two Aqua with USBL



Vehicles

- Six ASVs

Vehicles

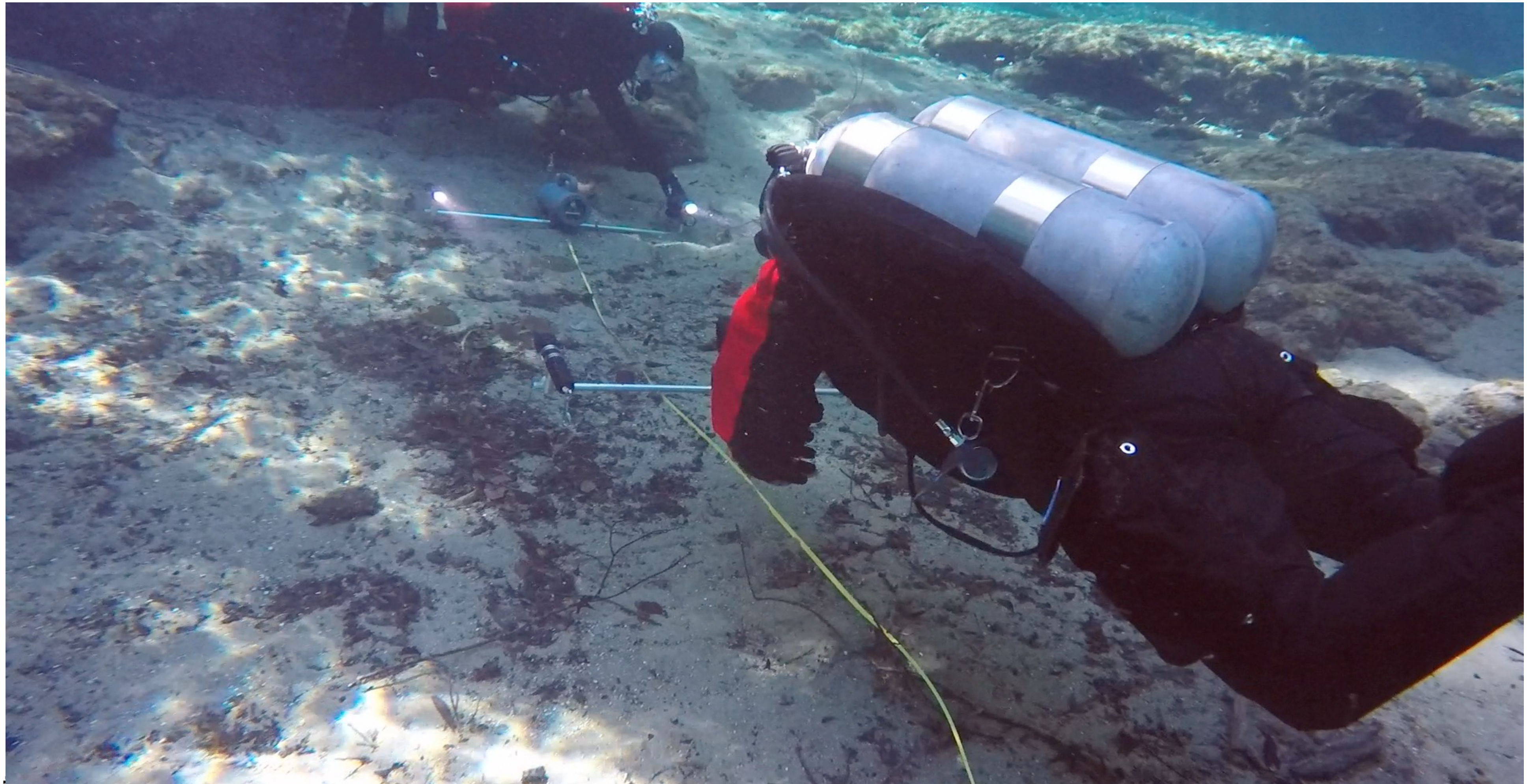
- Drones

Sensors

- Stereo Rig – 2017 (made at SC)

Sensors

- Cooperative Localization (made at SC)



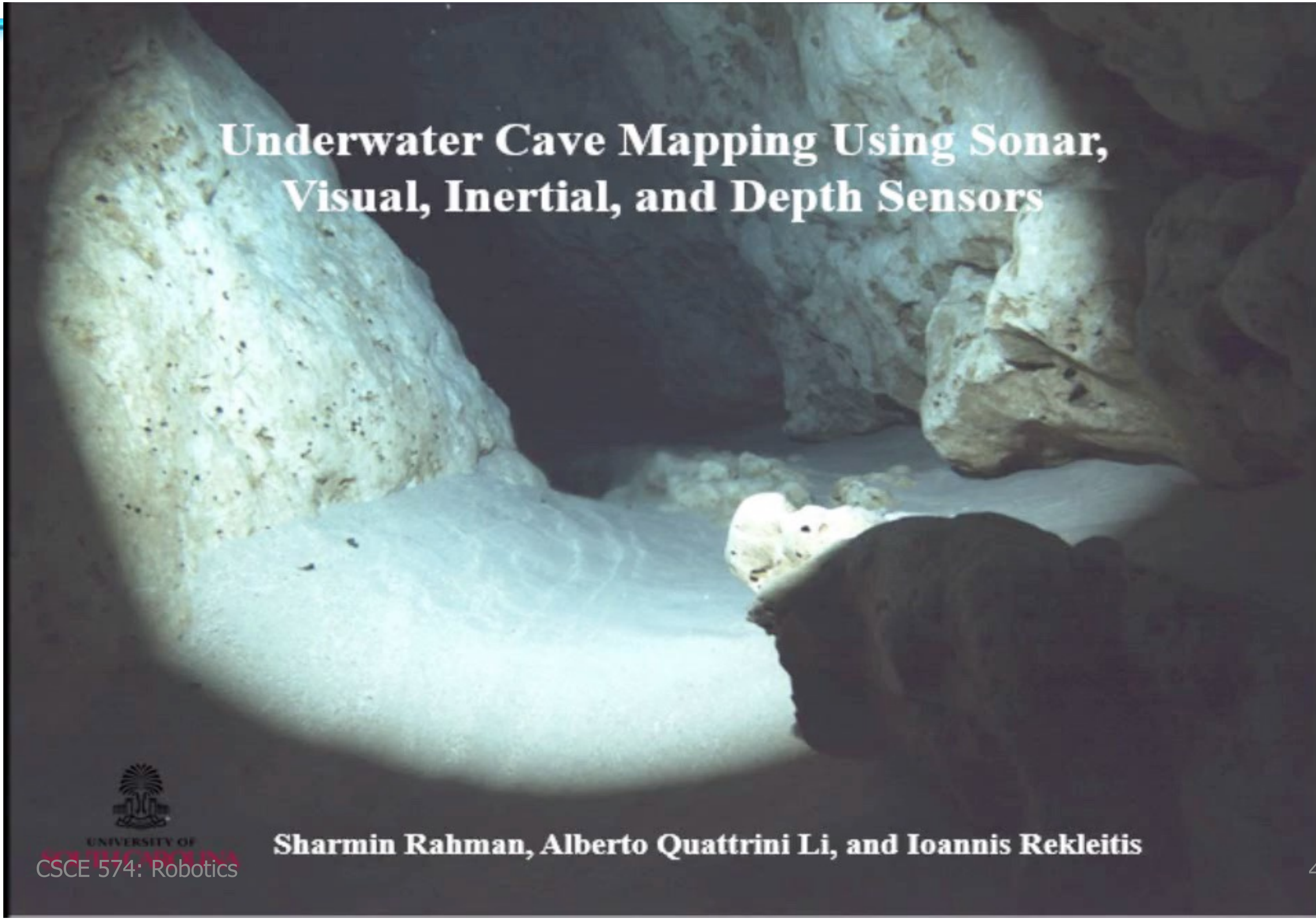
Shipwreck Mapping

Shipwreck Mapping

Robot's Eye View

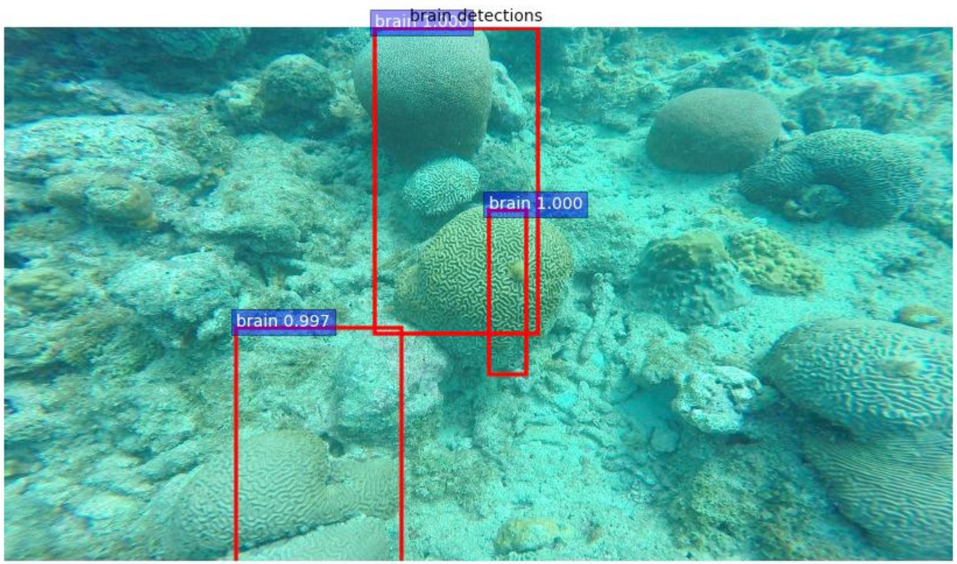
Underwater Cave Mapping

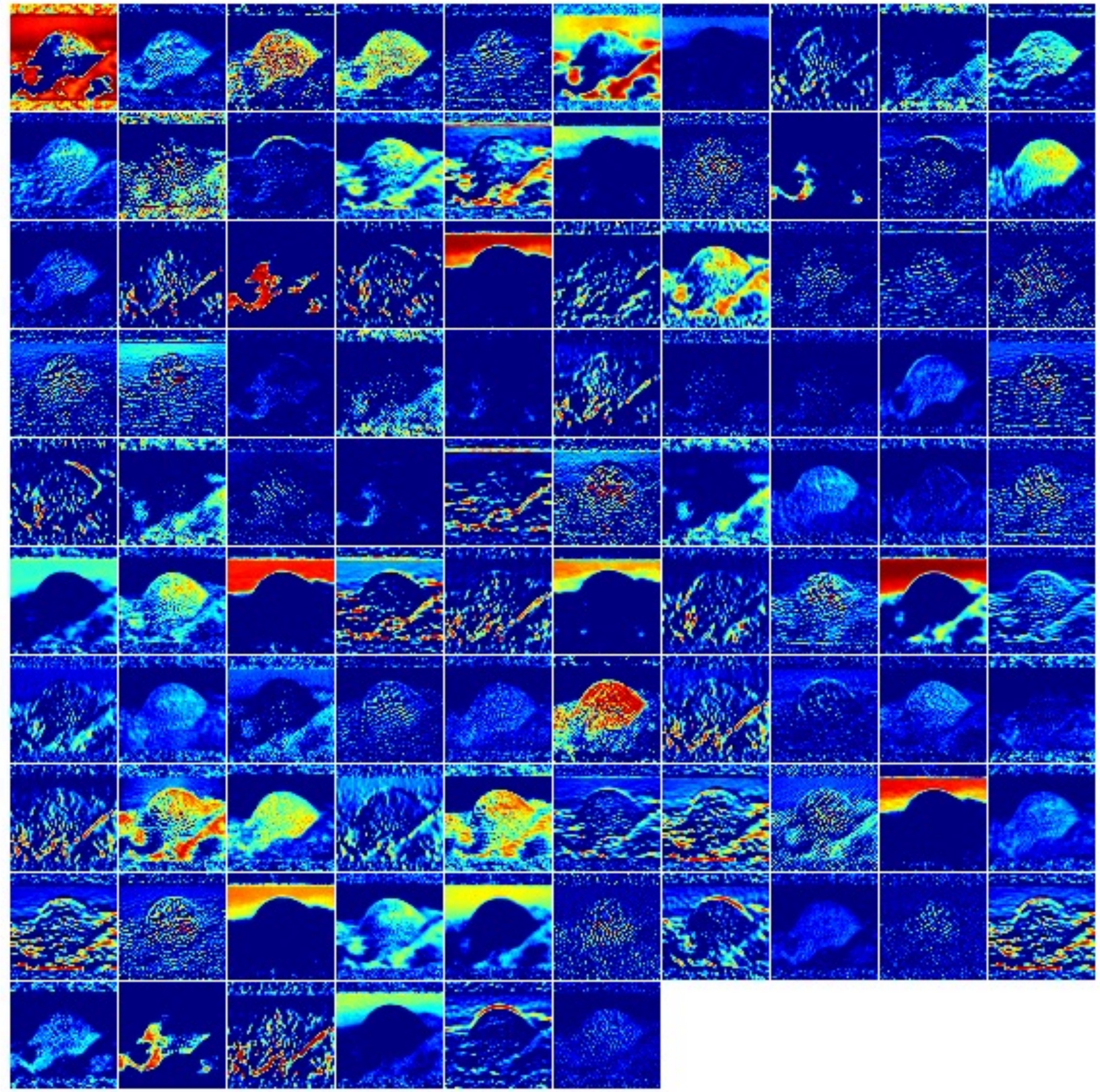
Underwater Cave Mapping



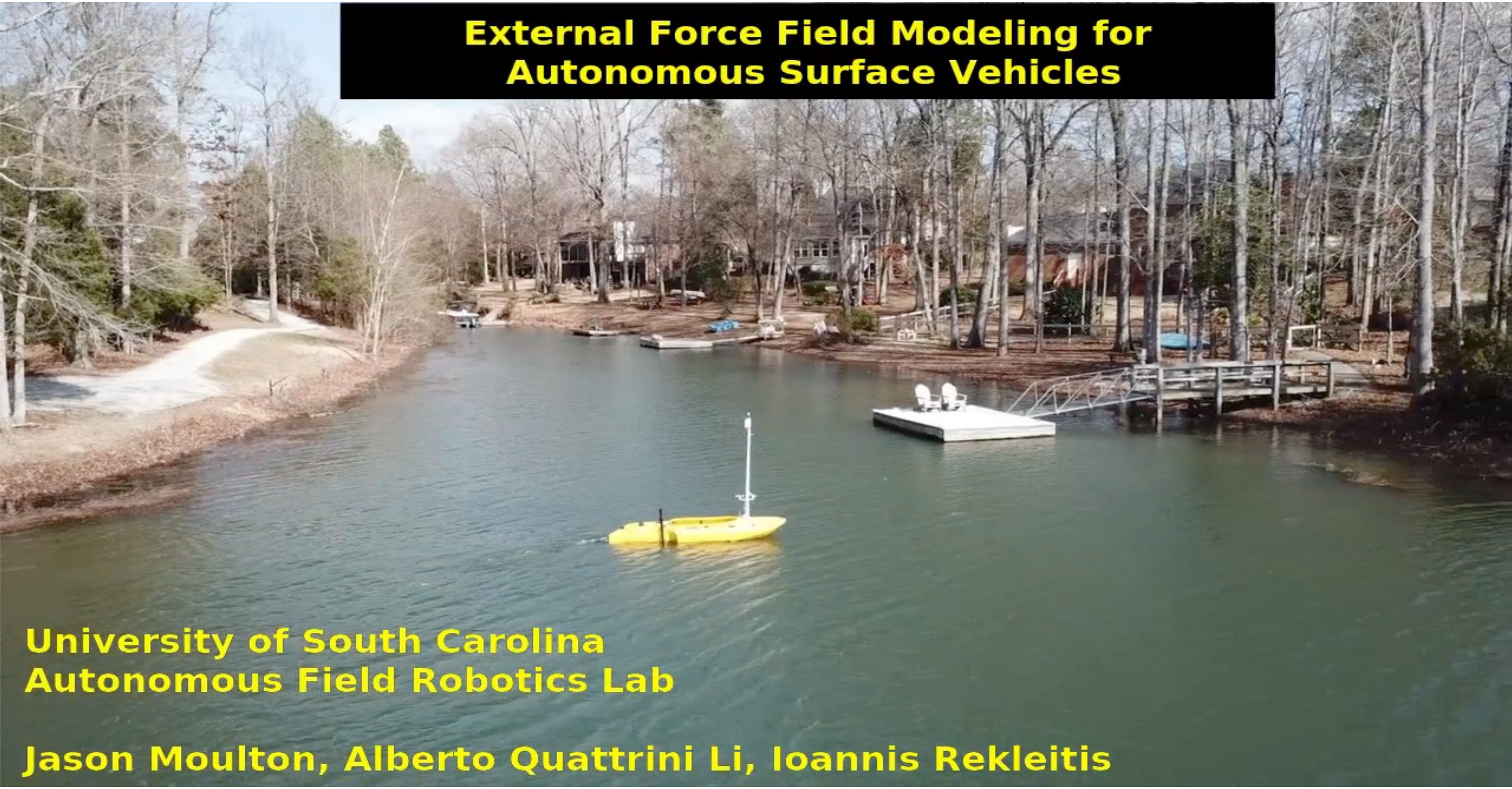
Shallow Coral Classification using Deep Learning

- Using a CNN

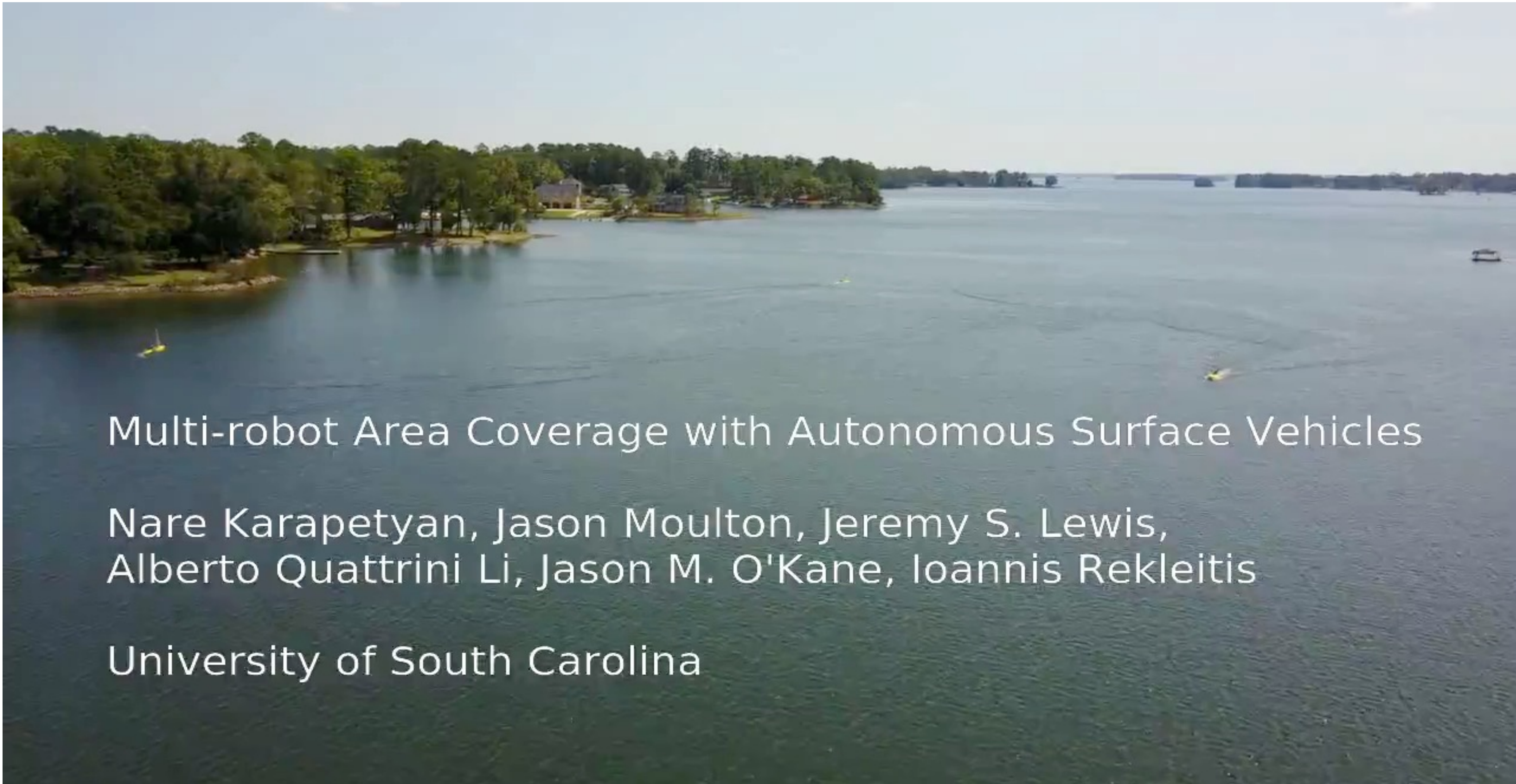




ASV Modeling of Adverse Conditions



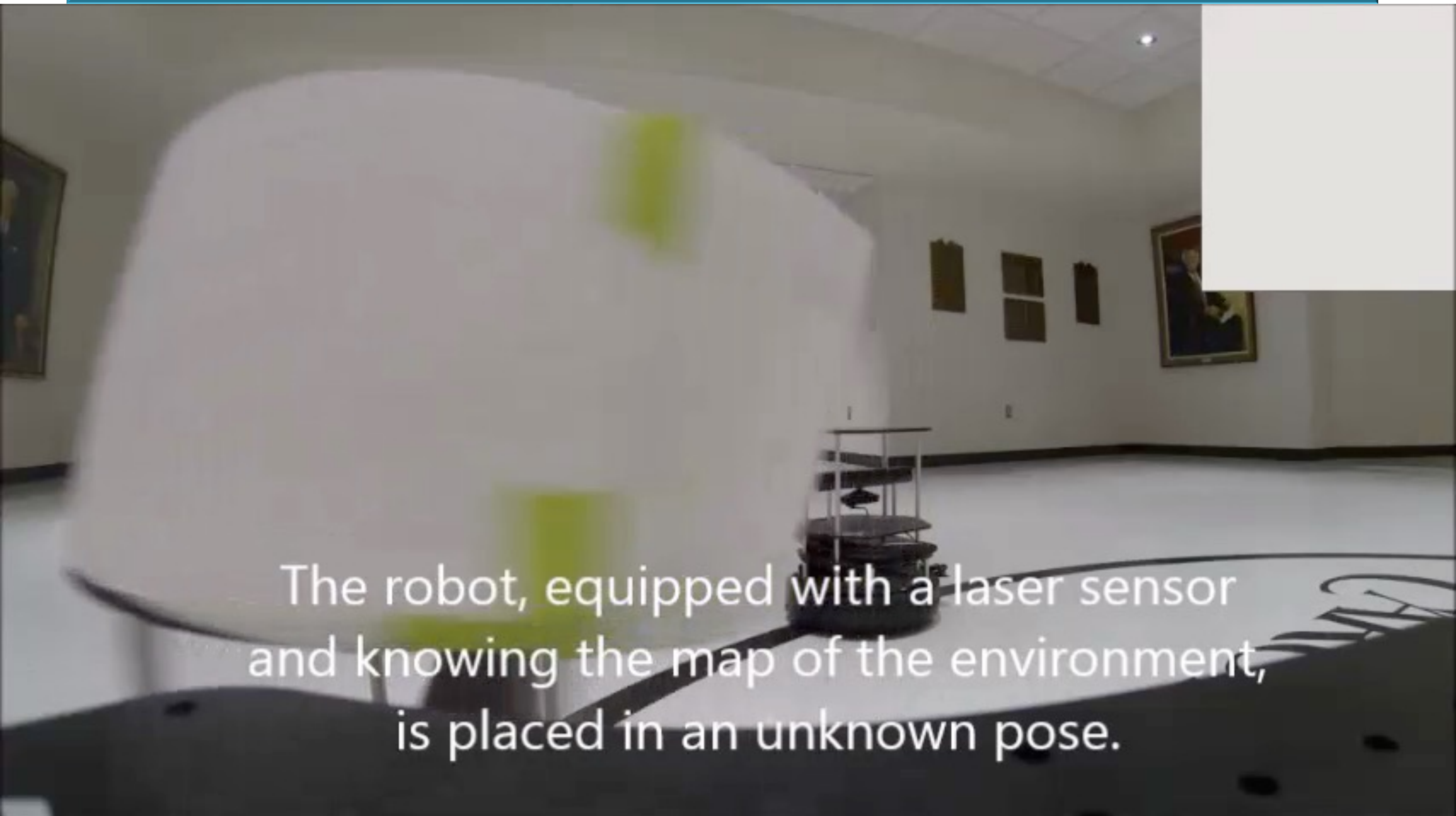
Single/Multi Robot Coverage
Dubins Vehicle kinematics



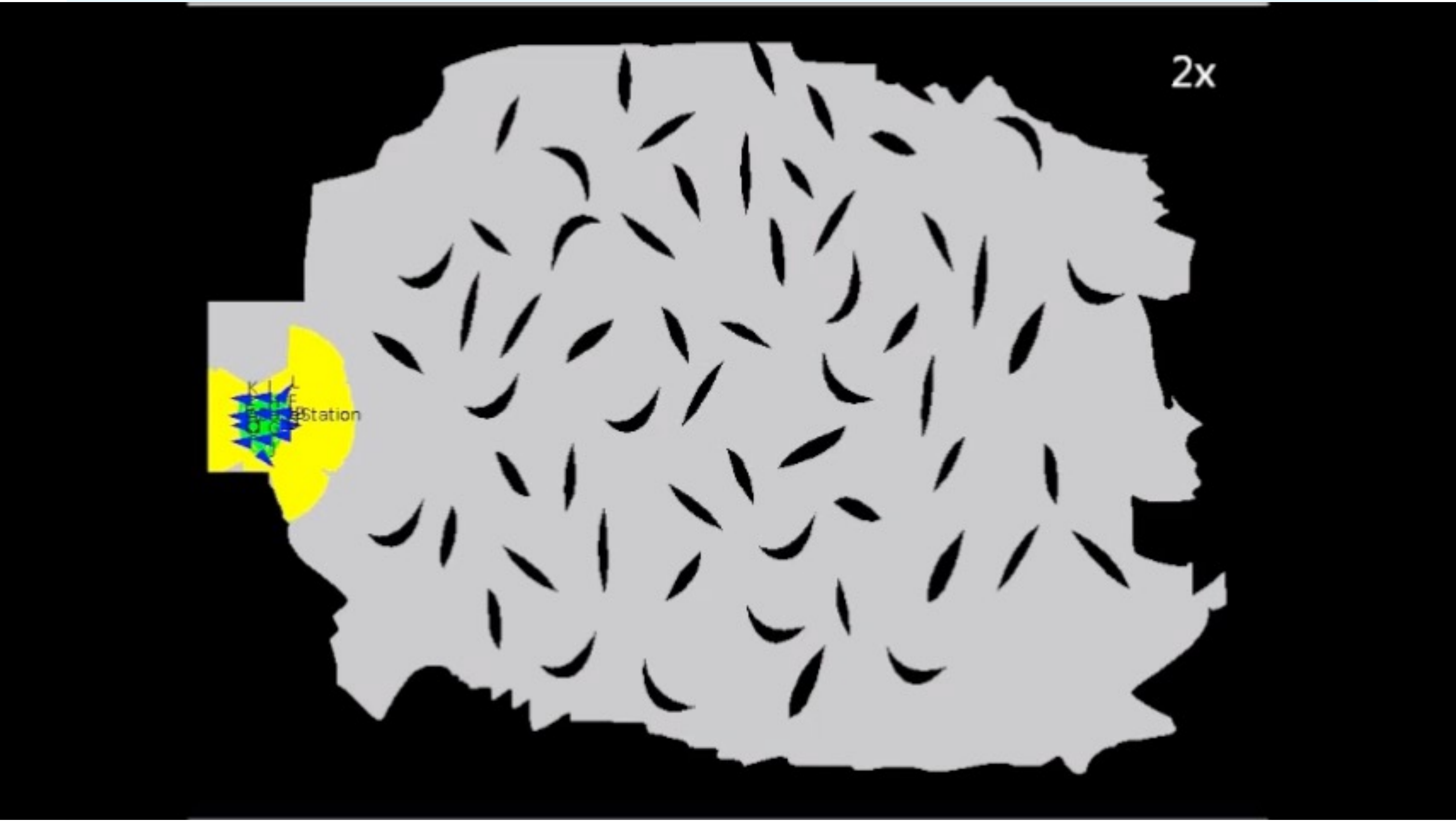
Marine Robotics:

HRI with limited bandwidth

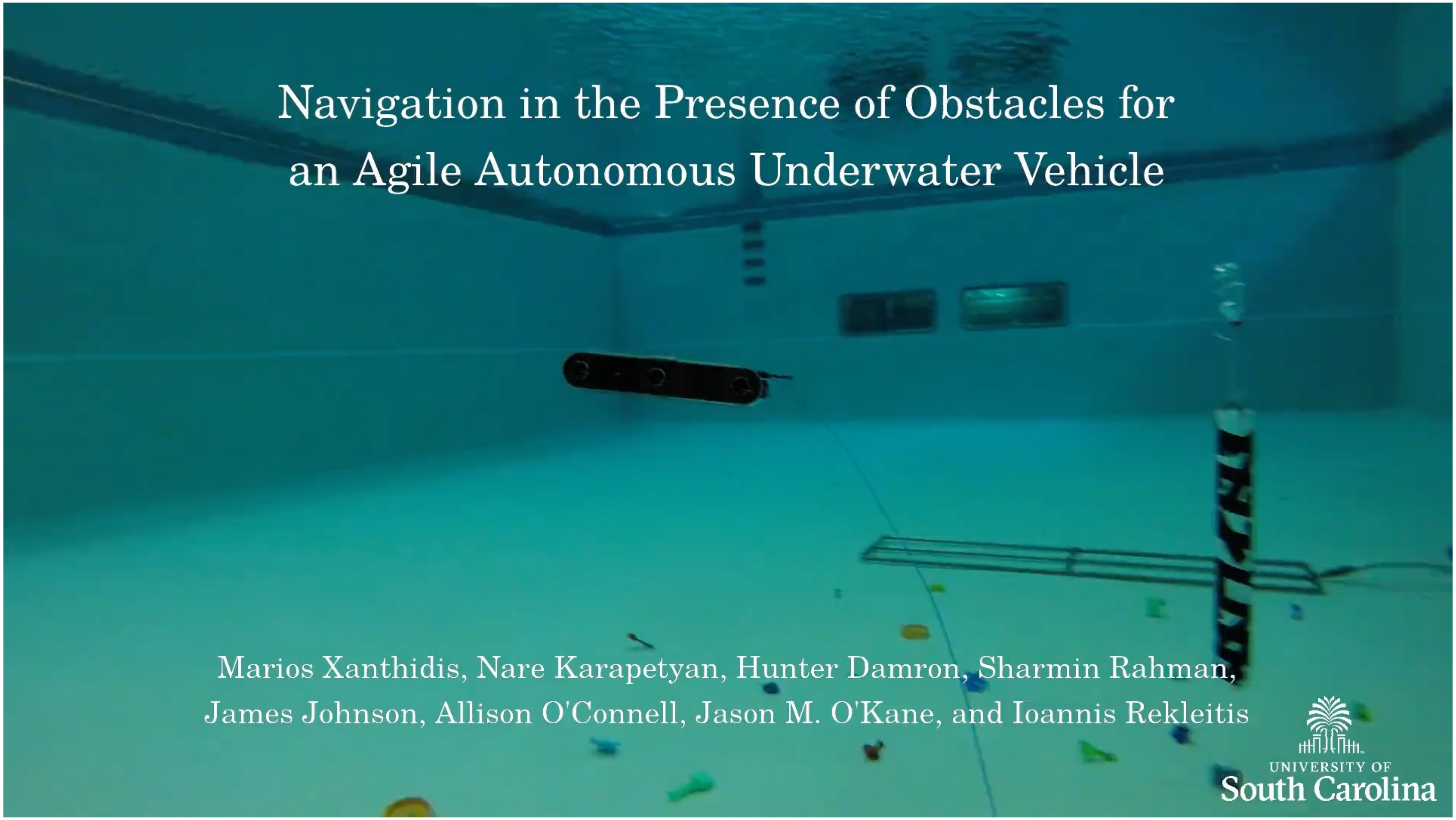
Indoor: Localization with dynamic obstacles



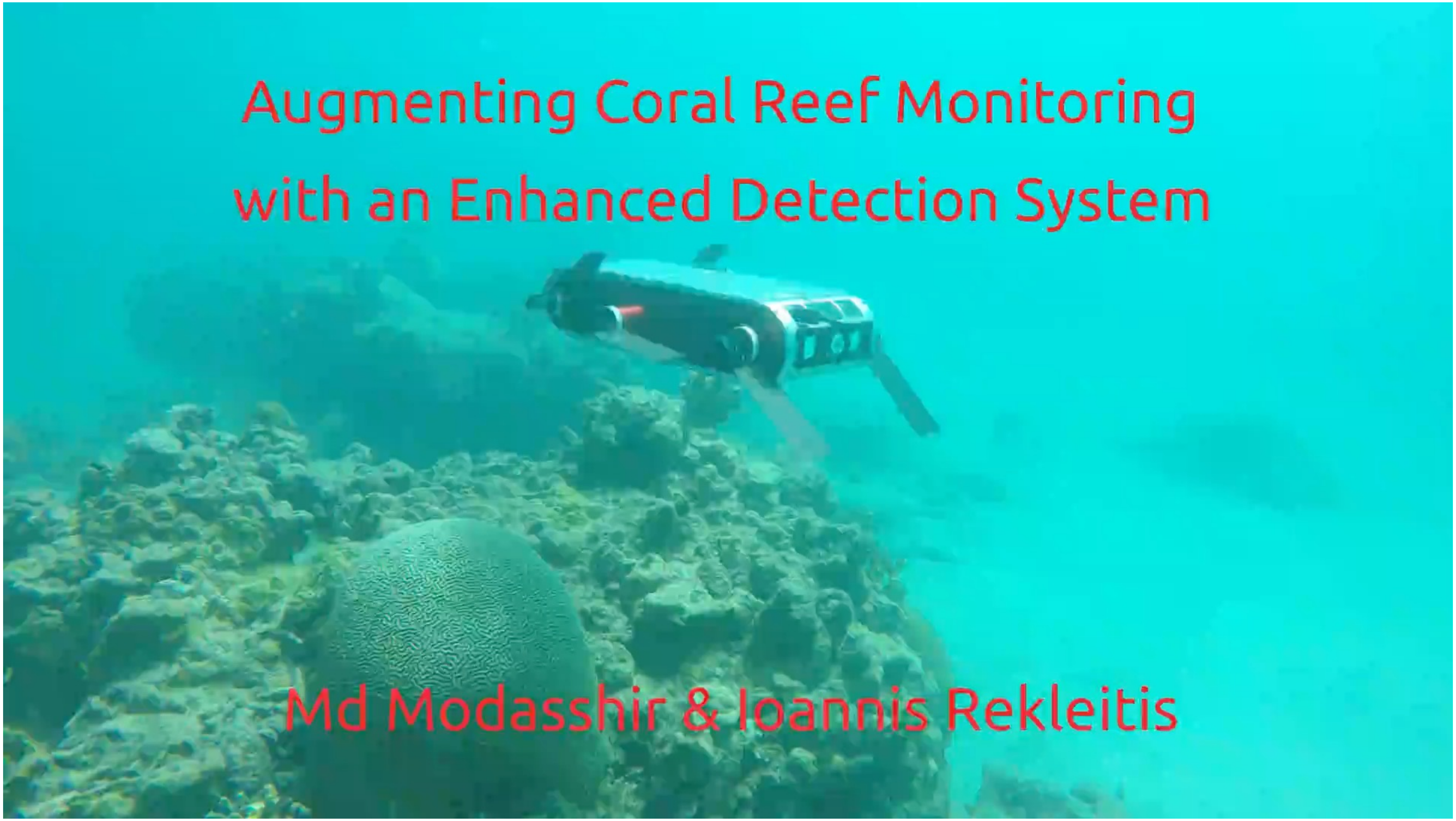
Indoor: Communication Constrained Exploration



Underwater Navigation



Coral Reef Monitoring



Riverine Coverage

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

Covid 19

- **"Face coverings will be required at all times inside all campus buildings, unless you are in your own residence hall room, private office or you are eating inside campus dining facilities. They are also required on shuttles, buses and other forms of university transportation."**

https://sc.edu/safety/coronavirus/safety_guidelines/index.php

Evaluation

- 5 Homeworks, 10% each: 50%
  - First two individual
  - Last three 50% team, 50% individual
- Final Examination: 30%
- Midterm: 20%

- **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/574/2021Fall/
- **Email**: yiannisr@cse.sc.edu

- **Office hours**: 2235– Mon/Wed 13:00-14:20

  and by appointment