



UNIVERSITY OF
SOUTH CAROLINA

CSCE 574 ROBOTICS

Introduction

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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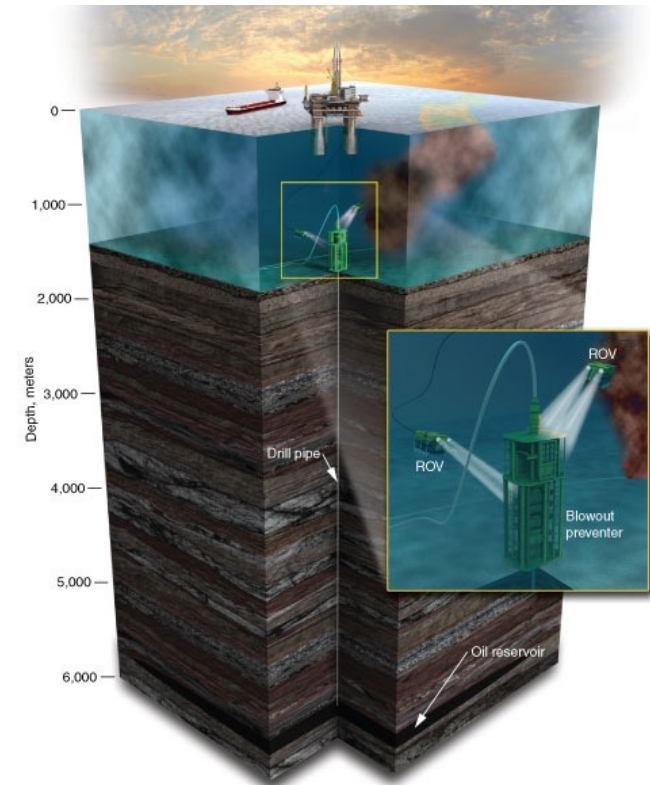
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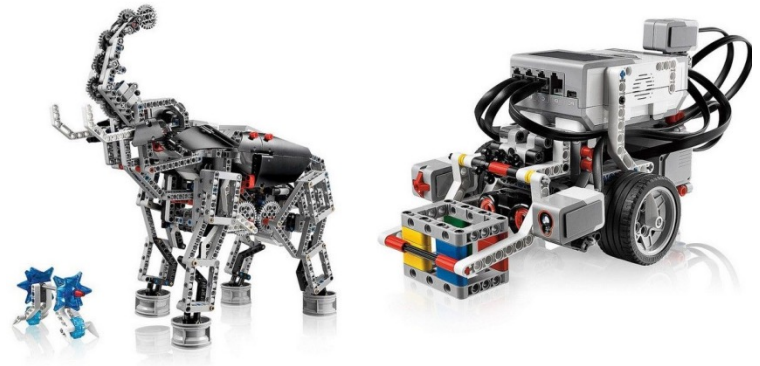
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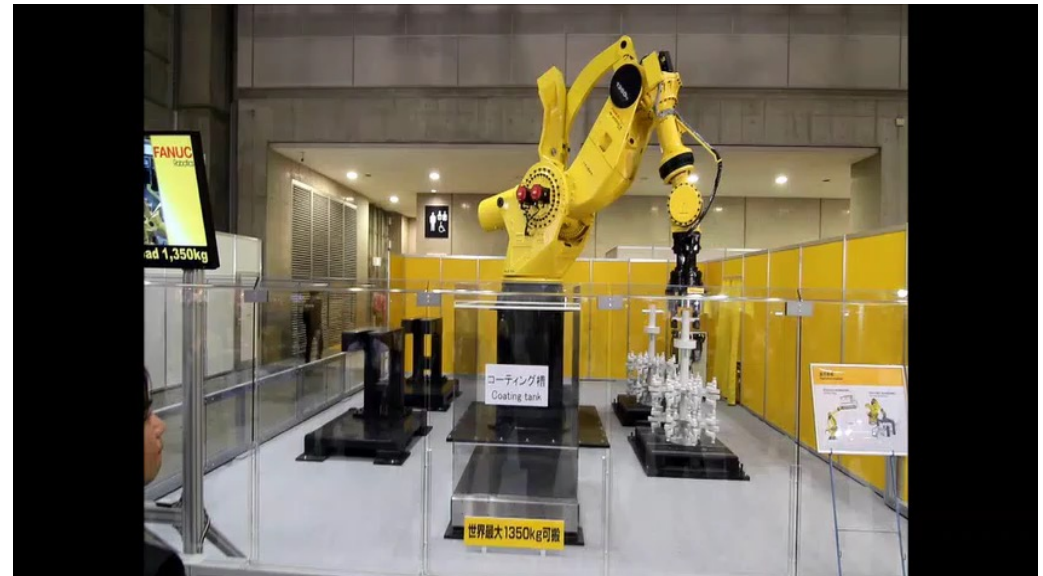
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Amazon bought Kiva for \$775M



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Robotic technology becomes affordable

TurtleBot 2



AR.DRONE



Kinect



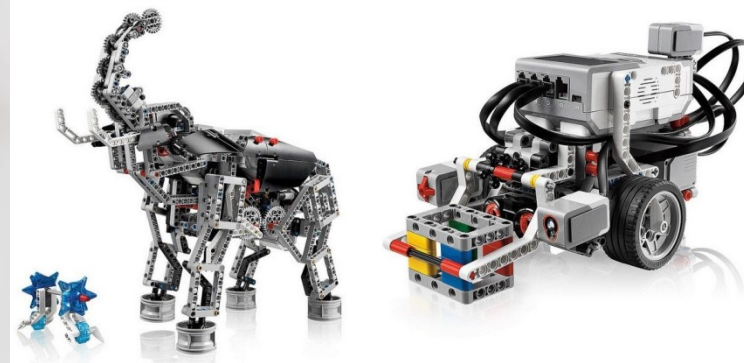
IMU



Raspberry Pi



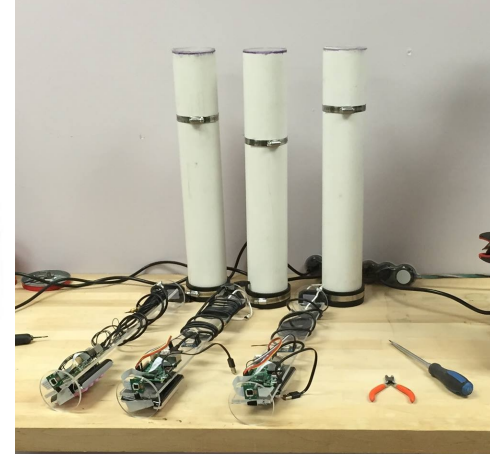
GPS



Lego Mindstorm

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



**Develop
algorithms for
robotic
applications**

Philosophy

**Evaluate performance
of the deployed robots**

**Deploy algorithms on
fielded robots**
(Aerial, ground, surface,
and/or underwater)



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**



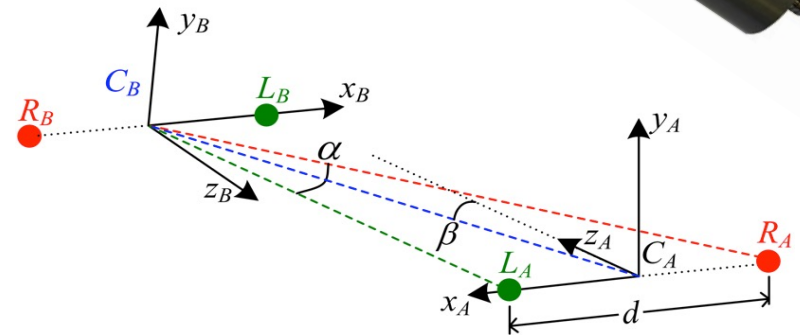
Recent Funding:

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

Stereo Based 3D Reconstruction



SONAR-Vision Fusion

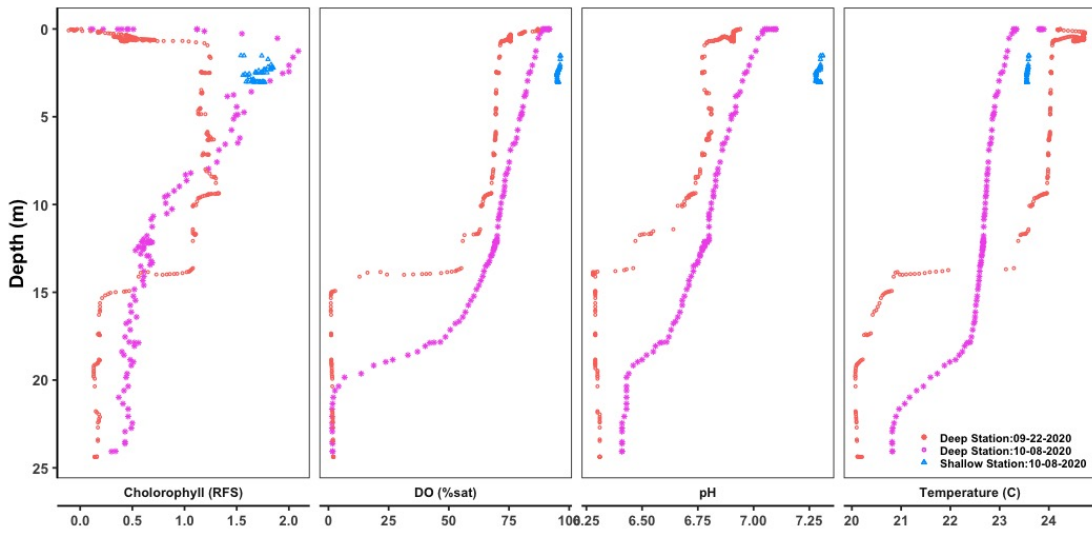


Cooperative Localization

Recent Funding:

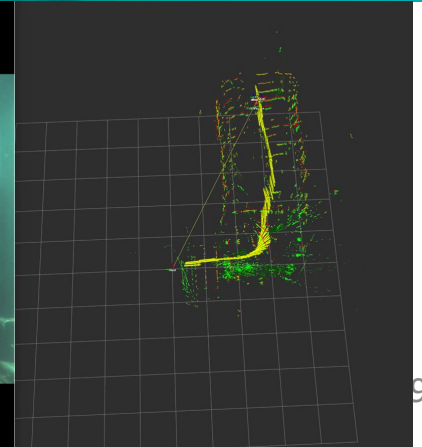
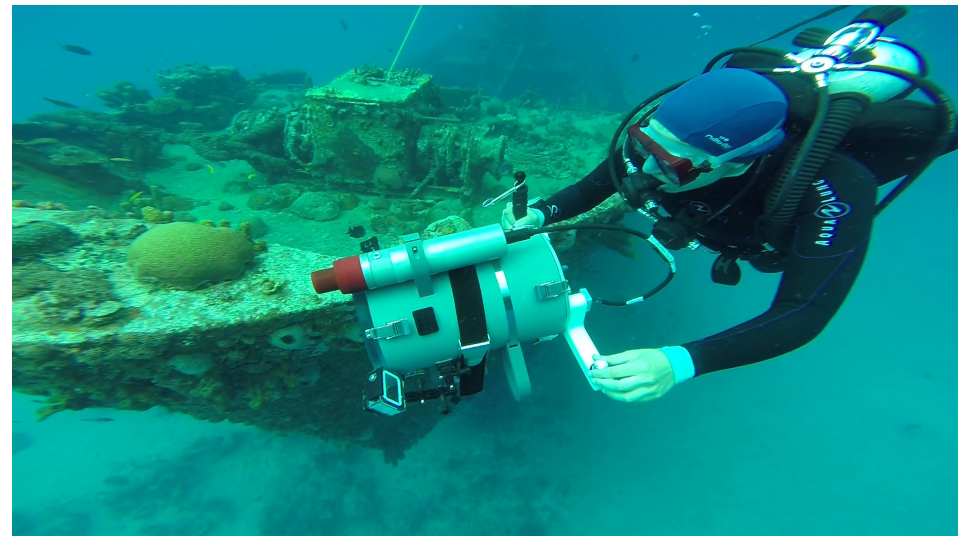


- **NSF RII Track-2 FEC:** Computational methods and autonomous robotics systems for modeling and predicting harmful cyanobacterial blooms.
- **Funding:** 2019-2023



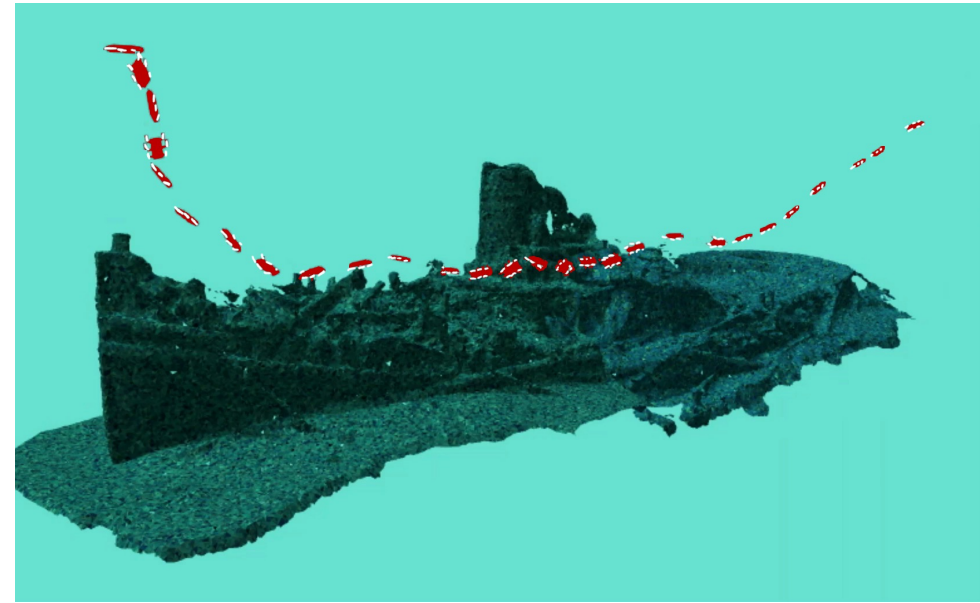
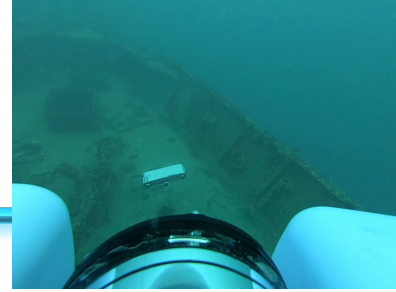
Recent Funding:

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

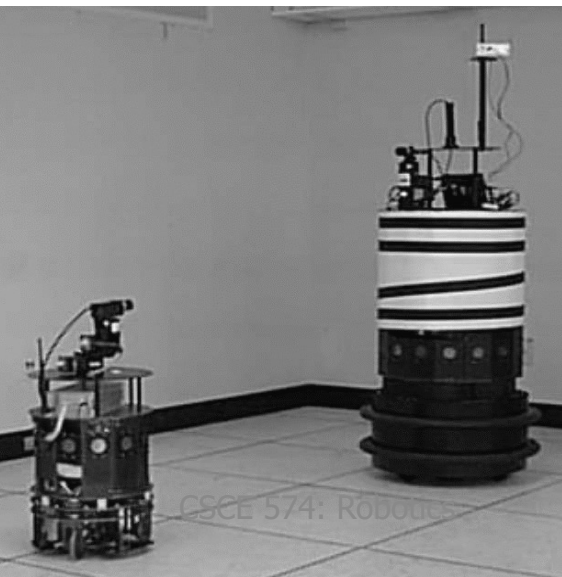
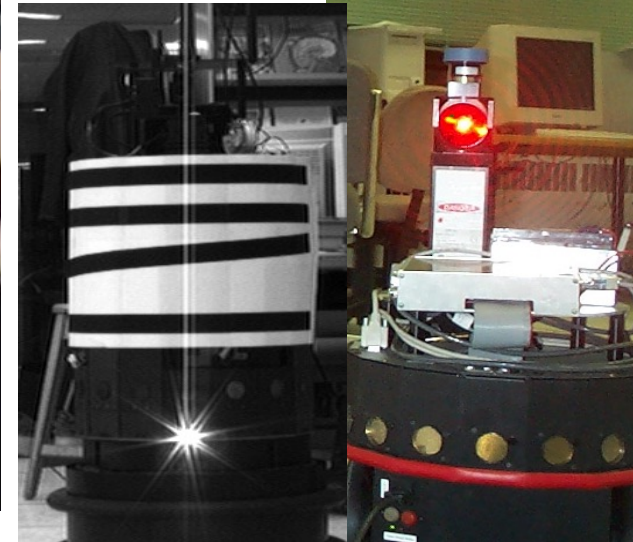
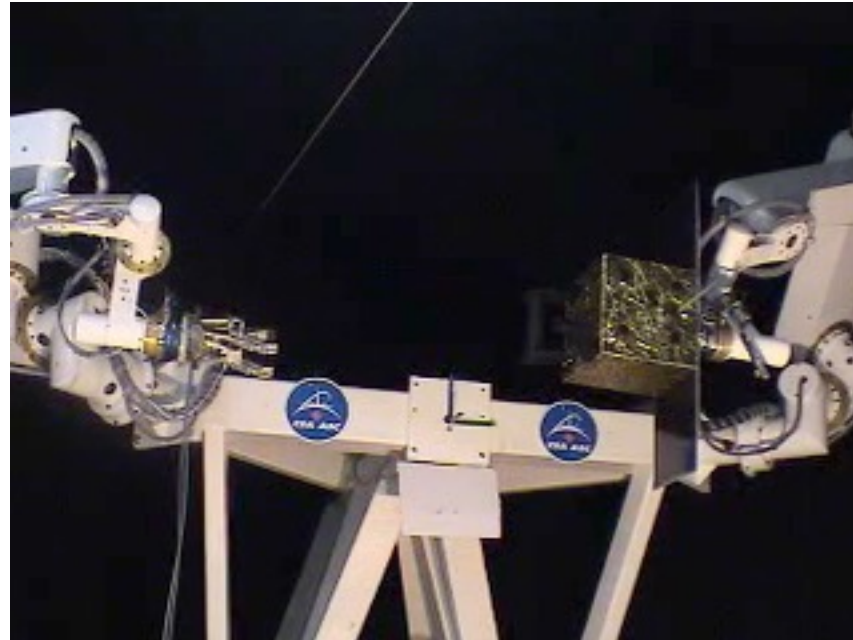


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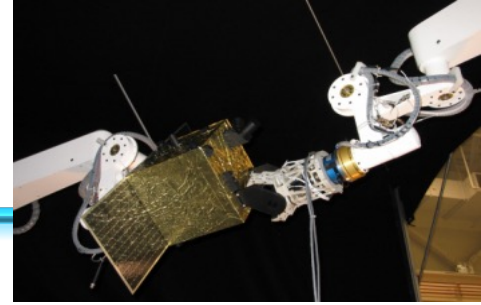
- **NSF Collaborative Research: NRI: INT: Cooperative Underwater Structure Inspection and Mapping**
- **Funding: 2020-2024**



Past Projects



Past Projects



**Complete Optimal Terrain Coverage
using an Unmanned Aerial Vehicle**

Anqi Xu
Chatavut Viriyasuthee
Ioannis Rekleitis



The MARE ASV serves as a surface relay station
between the Unicorn UAV and the Aqua AUV





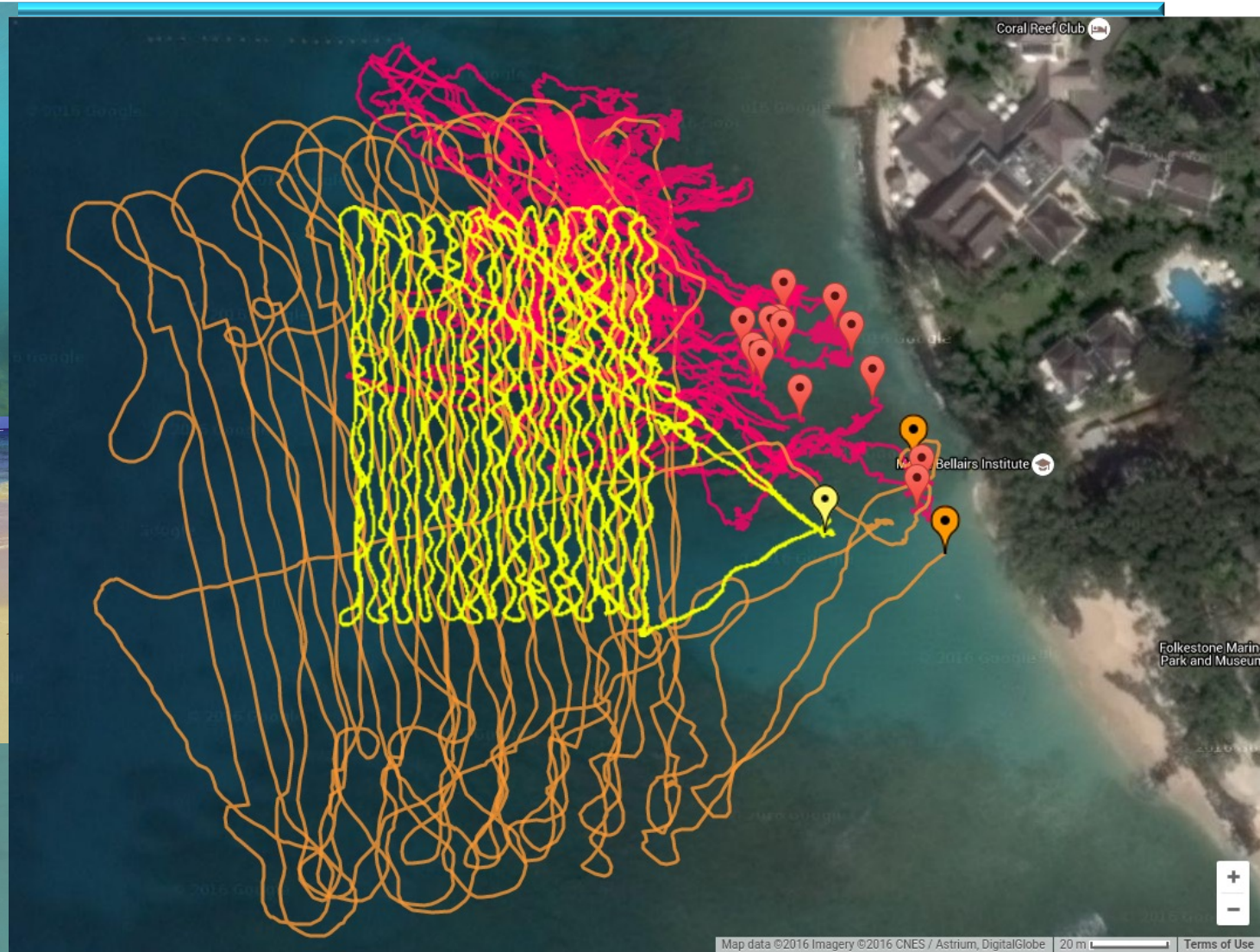
Aerial Robotics

Cooperative Localization

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



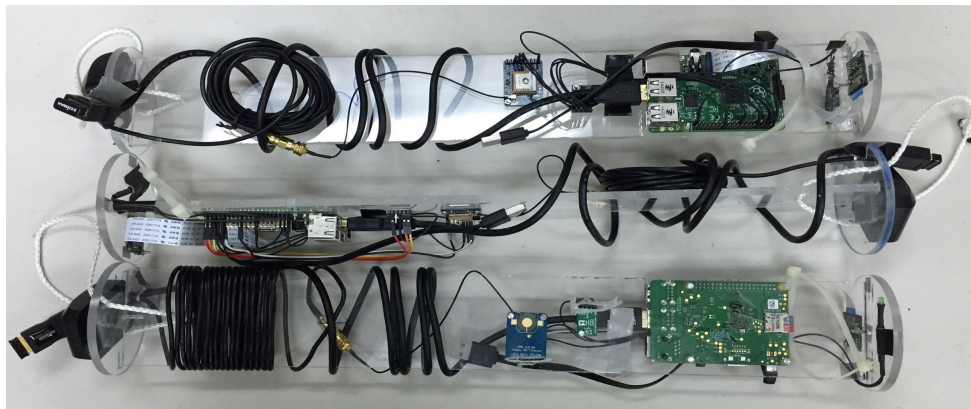
Coral Reef Monitoring by Heterogeneous Robots



Marine Robotics

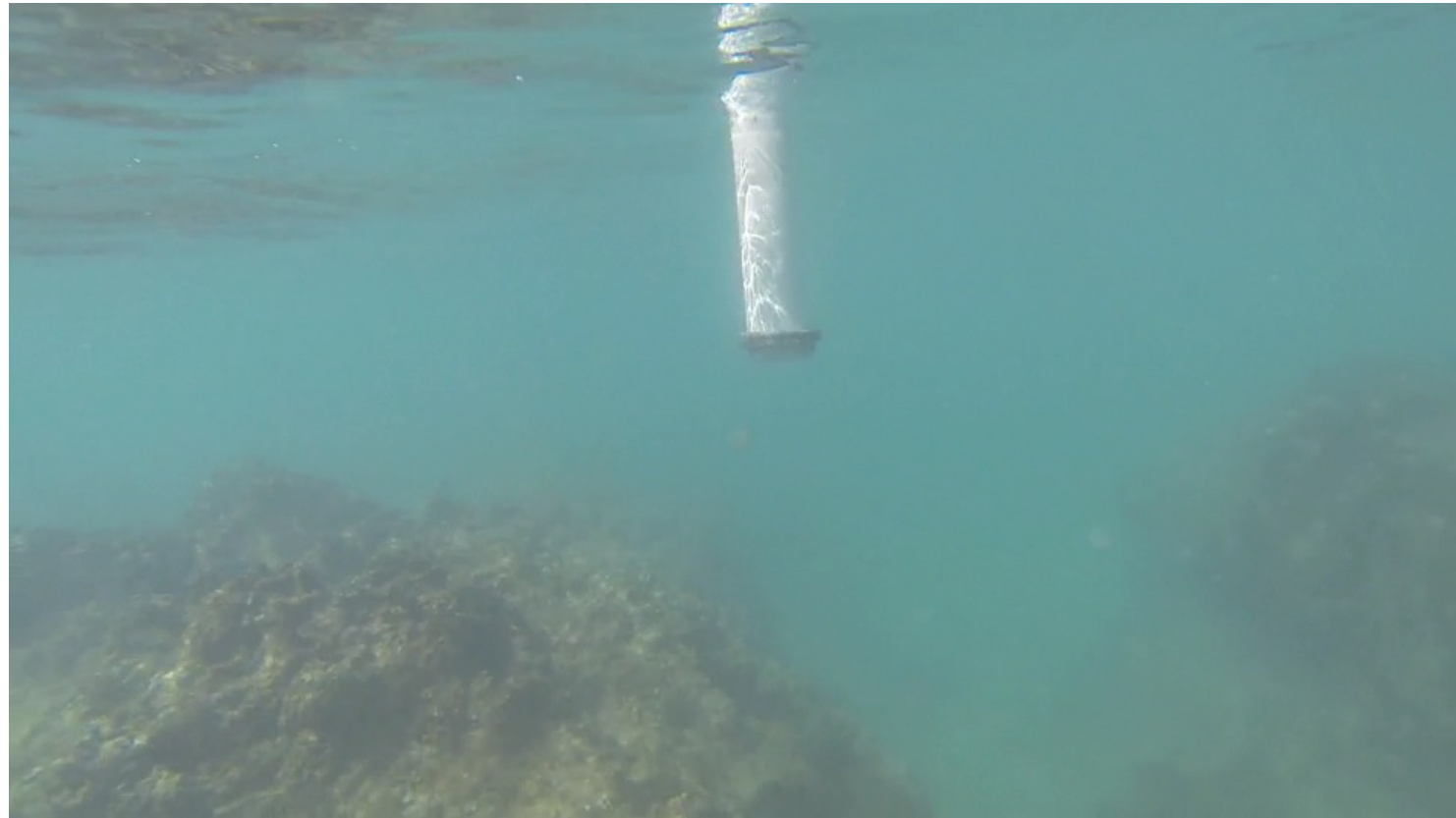
Capstone Project: Drift Nodes

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



Marine Robotics: Drift Nodes

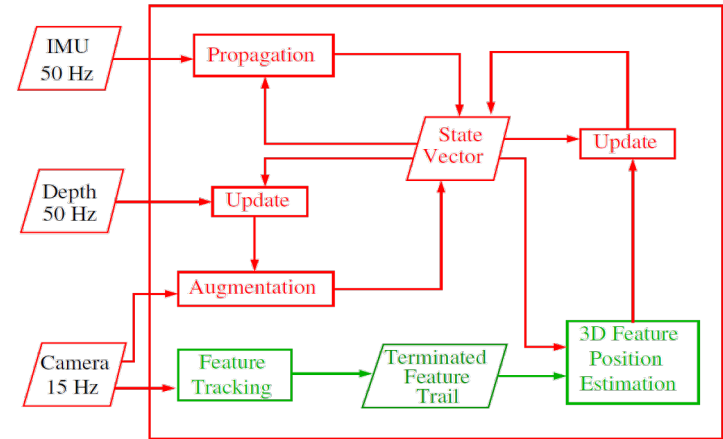
- Monitor, shallow coral reefs.
- Improve estimation accuracy



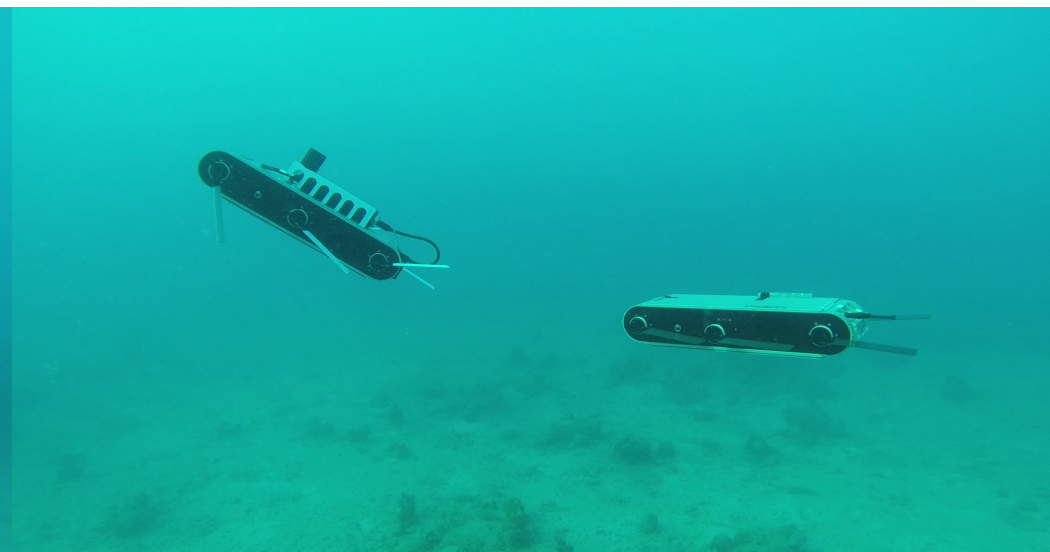
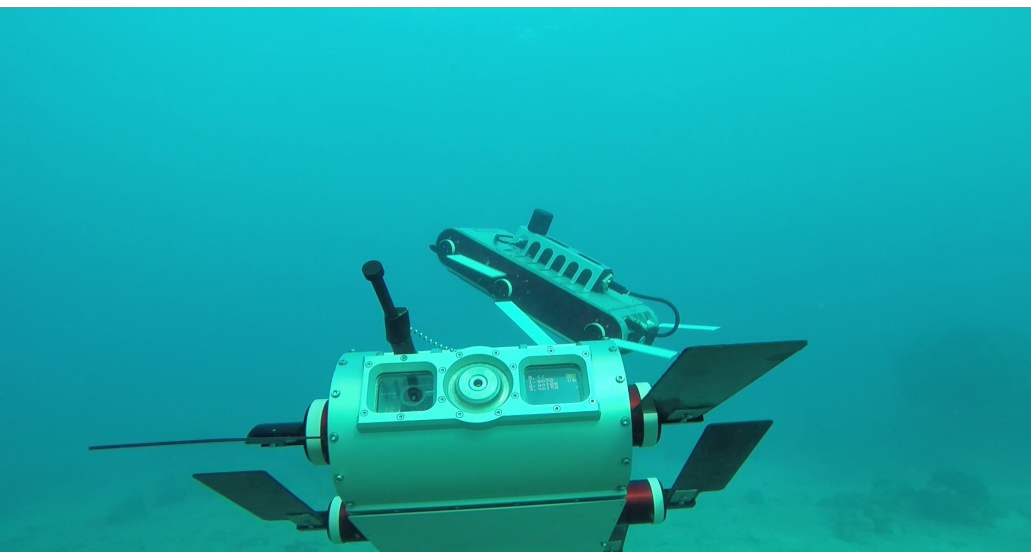
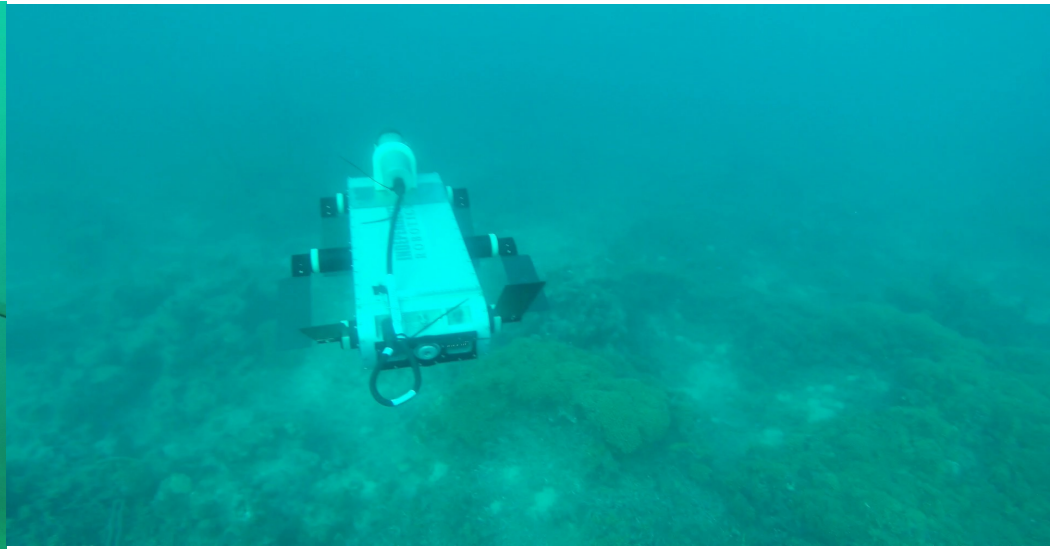
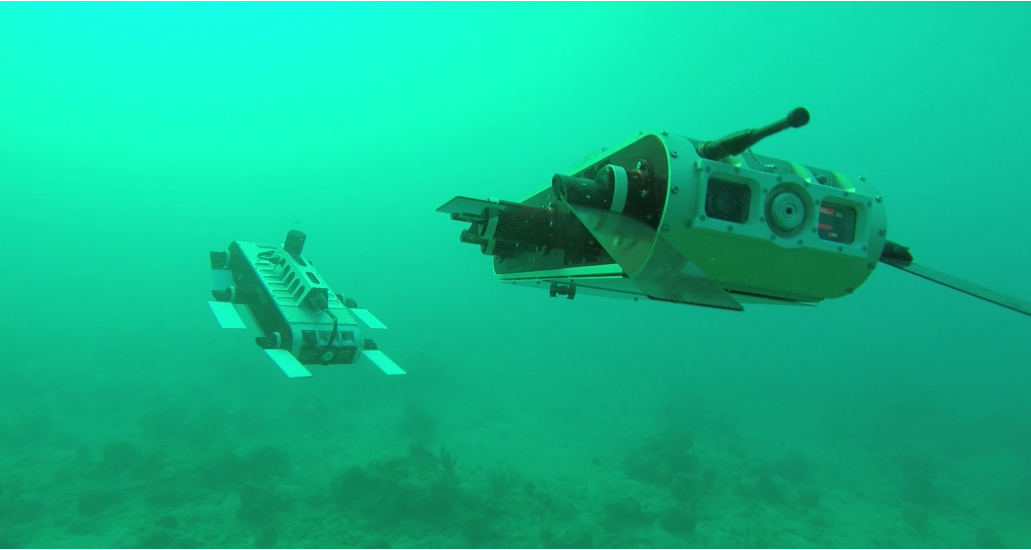
Marine Robotics

Underwater Situational Awareness

- Vision-INS State Estimation
- Path Planning
- Mapping

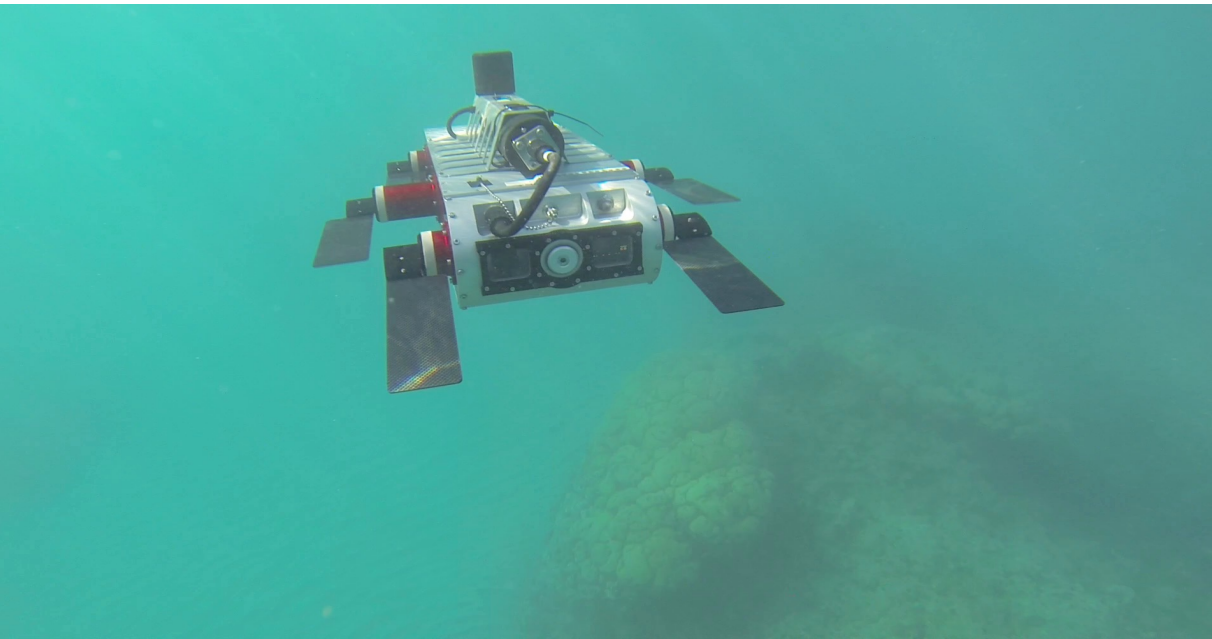


Marine Robotics



Vehicles

- Two Aqua with USBL



Vehicles

- Six ASVs



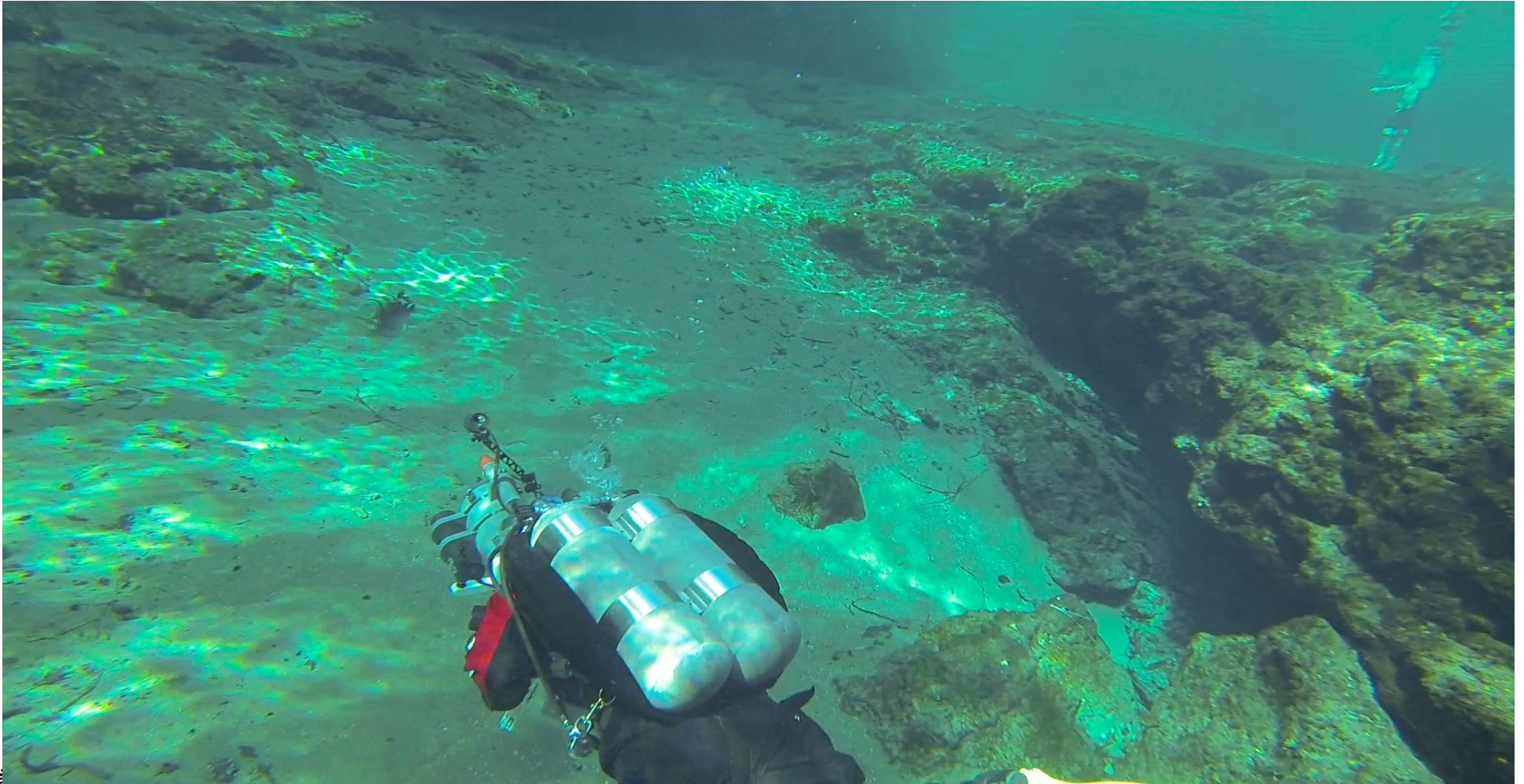
Vehicles

- Drones



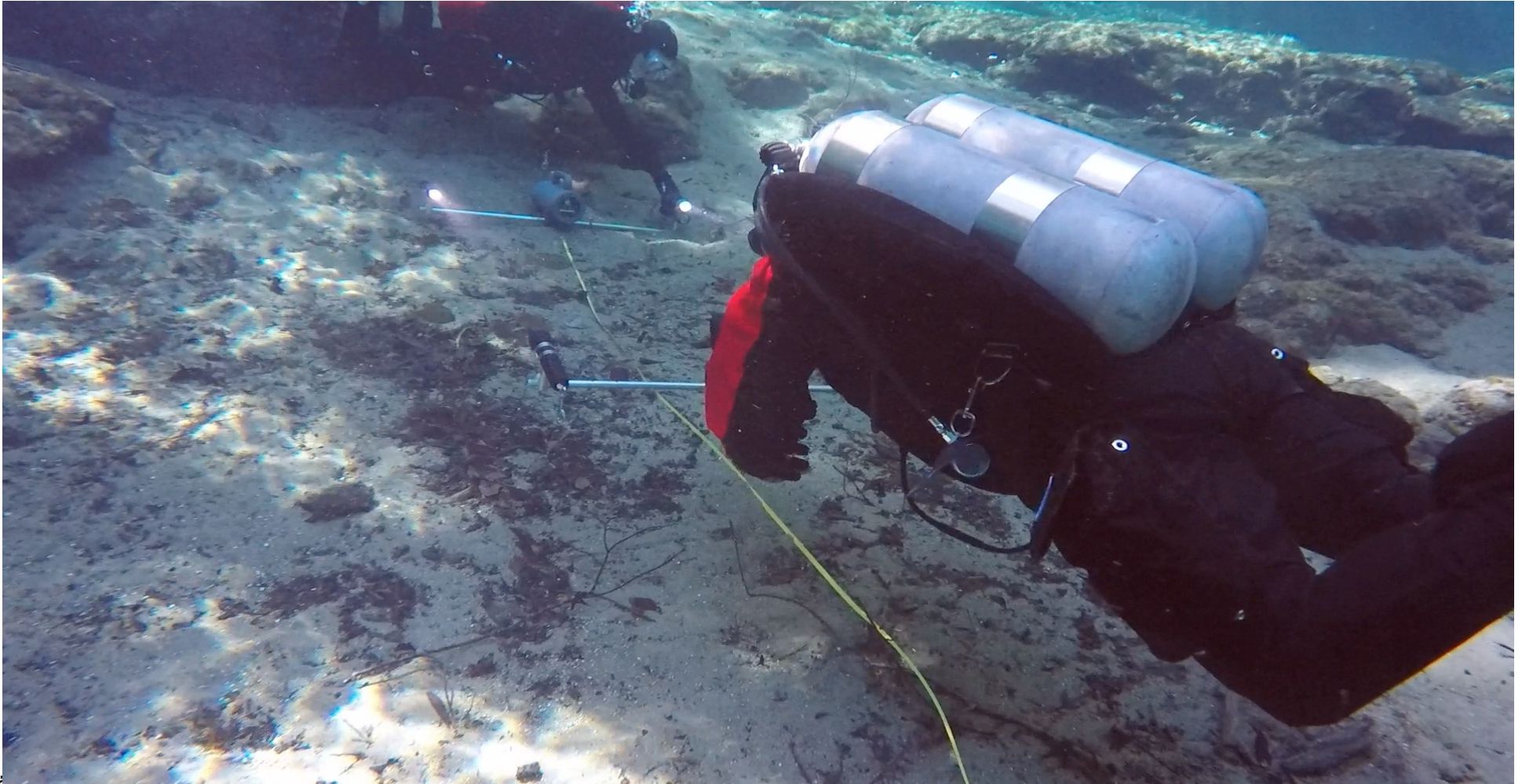
Sensors

- Stereo Rig – 2017 (made at SC)



Sensors

- Cooperative Localization (made at SC)



Shipwreck Mapping



Shipwreck Mapping

Robot's Eye View



Underwater Cave Mapping

An underwater photograph of a cave interior. The scene is dimly lit, with a diver visible in the center, illuminated by a light source. The cave walls are covered in intricate, branching patterns, likely stalactites or mineral deposits. The water is dark blue, and the overall atmosphere is mysterious and exploratory.

Cave Mapping using Stereo Vision

Nick Weidner, Sharmin Rahman, Alberto Quattrini Li, and Ioannis Rekleitis

Underwater Cave Mapping

**Underwater Cave Mapping Using Sonar,
Visual, Inertial, and Depth Sensors**



UNIVERSITY OF

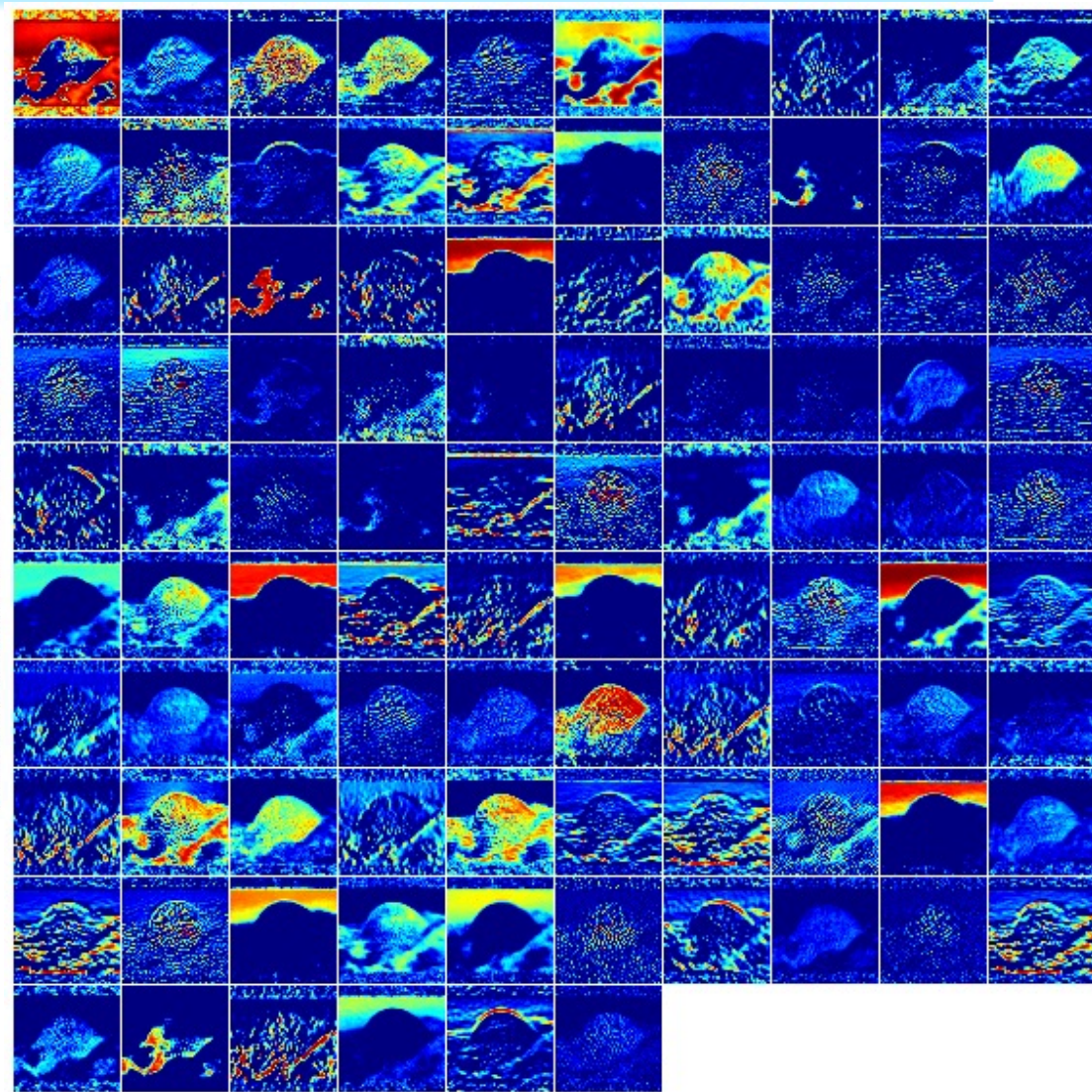
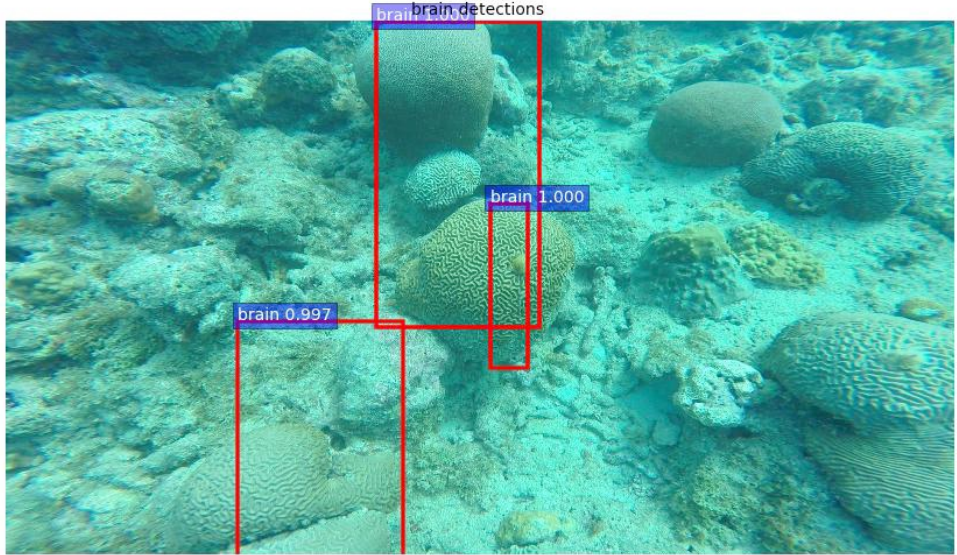
CSCE 574: Robotics

Sharmin Rahman, Alberto Quattrini Li, and Ioannis Rekleitis



Shallow Coral Classification using Deep Learning

- Using a CNN



ASV Modeling of Adverse Conditions

**External Force Field Modeling for
Autonomous Surface Vehicles**



**University of South Carolina
Autonomous Field Robotics Lab**

Jason Moulton, Alberto Quattrini Li, Ioannis Rekleitis



Single/Multi Robot Coverage

Dubins Vehicle kinematics



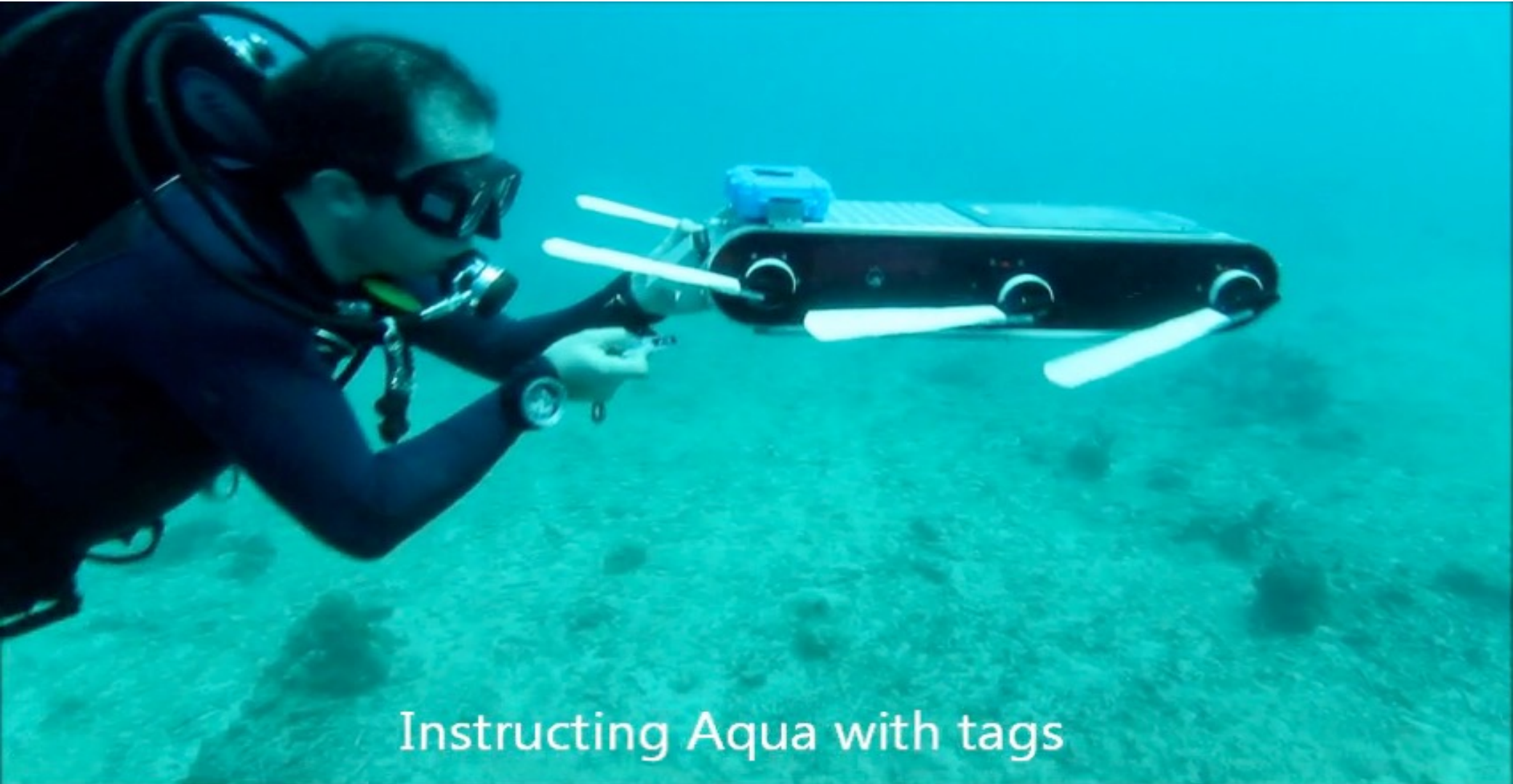
Multi-robot Area Coverage with Autonomous Surface Vehicles

Nare Karapetyan, Jason Moulton, Jeremy S. Lewis,
Alberto Quattrini Li, Jason M. O'Kane, Ioannis Rekleitis

University of South Carolina

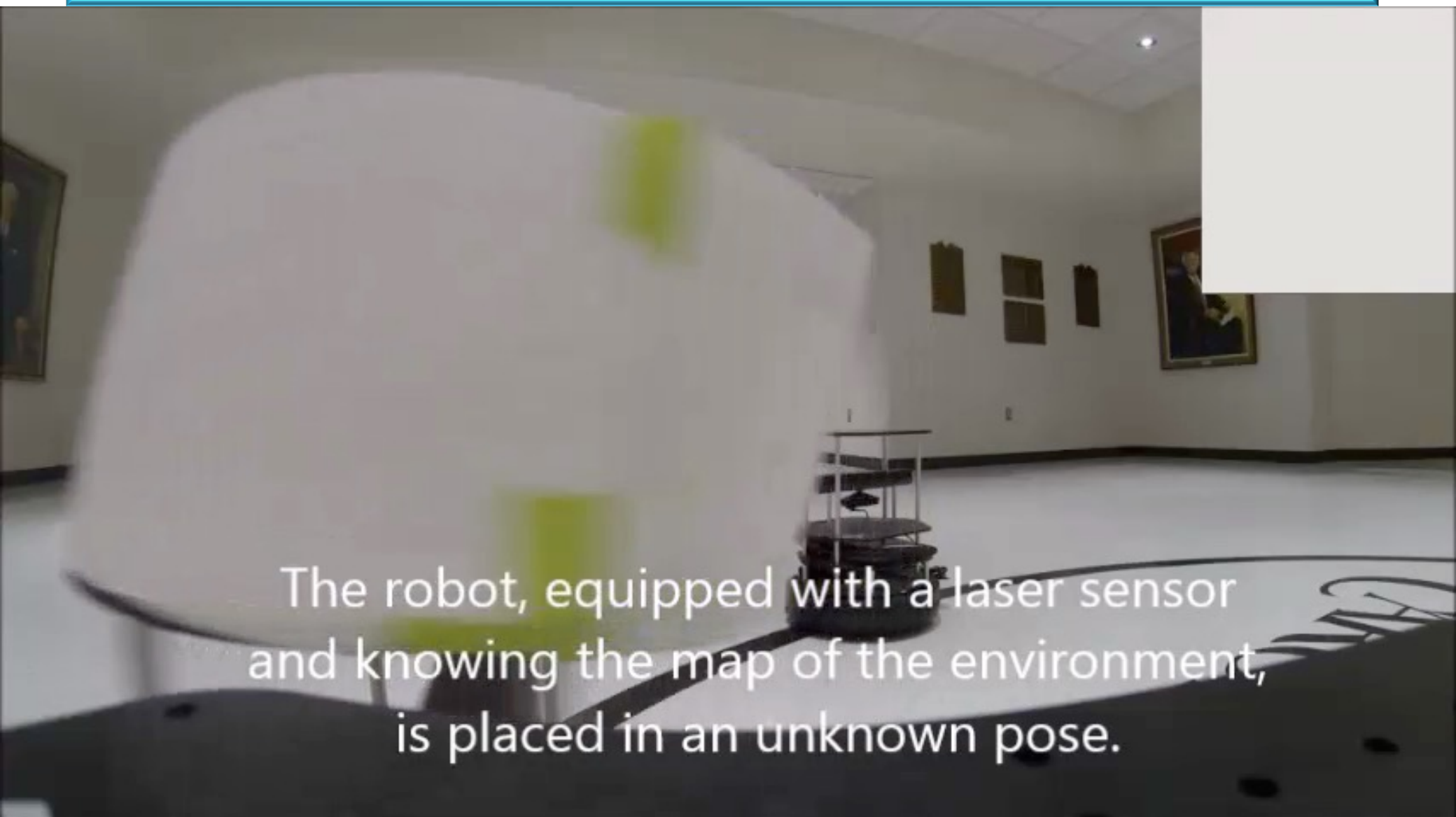
Marine Robotics:

HRI with limited bandwidth



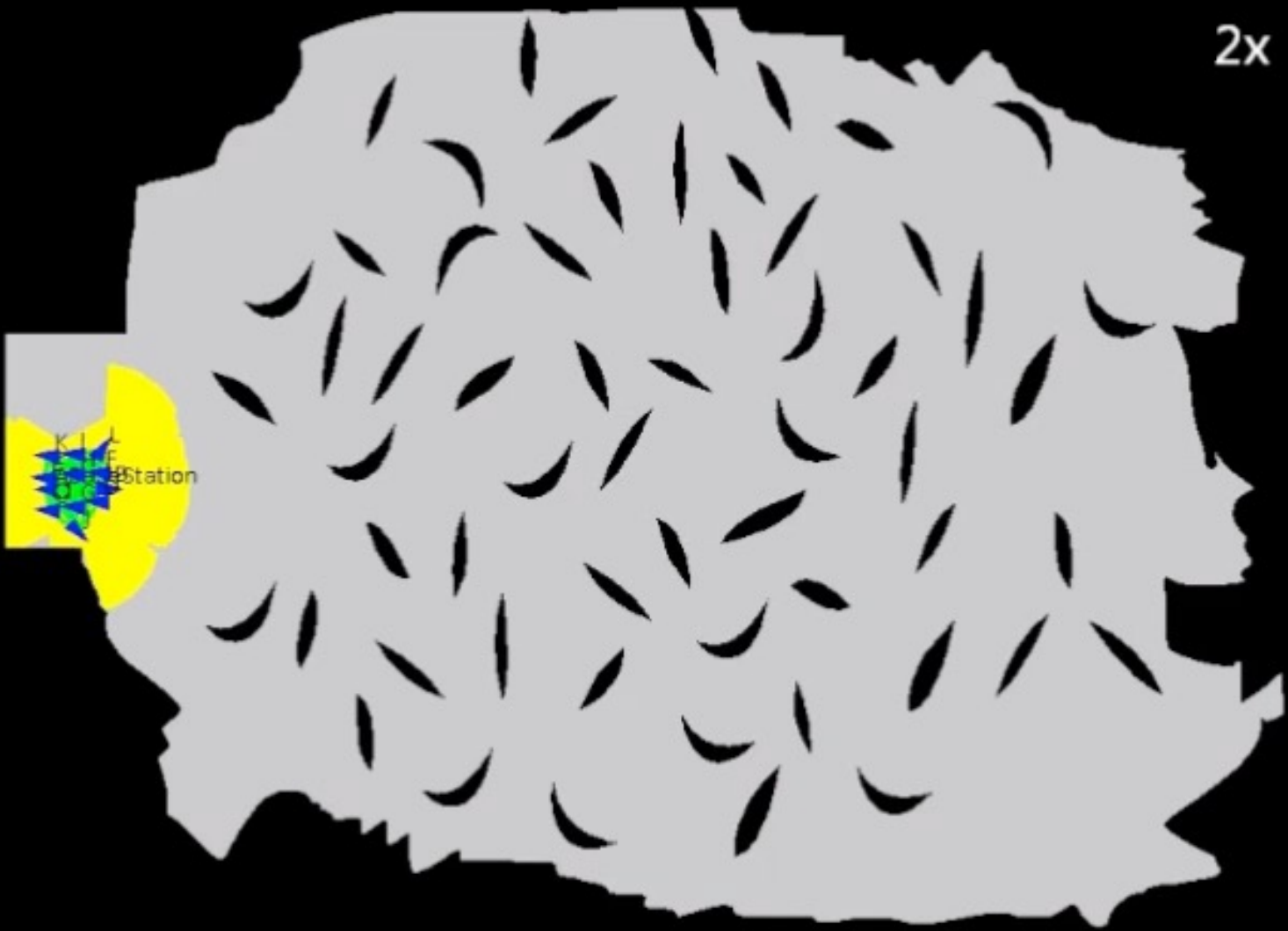
Instructing Aqua with tags

Indoor: Localization with dynamic obstacles

A mobile robot is positioned in a hallway. A large, white, semi-transparent obstacle is in the foreground, partially obscuring the view. The robot is a small, dark, cylindrical device with a metal frame on top. The hallway has white walls, a dark baseboard, and a light-colored floor. There are framed pictures on the wall and a circular logo on the floor. The text is overlaid on the bottom half of the image.

The robot, equipped with a laser sensor and knowing the map of the environment, is placed in an unknown pose.

Indoor: Communication Constrained Exploration



Underwater Navigation

Navigation in the Presence of Obstacles for
an Agile Autonomous Underwater Vehicle

Marios Xanthidis, Nare Karapetyan, Hunter Damron, Sharmin Rahman,
James Johnson, Allison O'Connell, Jason M. O'Kane, and Ioannis Rekleitis



Coral Reef Monitoring

Augmenting Coral Reef Monitoring
with an Enhanced Detection System

Md Modasshir & Ioannis Rekleitis



Riverine Coverage

