



UNIVERSITY OF  
**SOUTH CAROLINA**

# **CSCE 574 ROBOTICS**

## **Introduction**

# Why Robotics?

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- 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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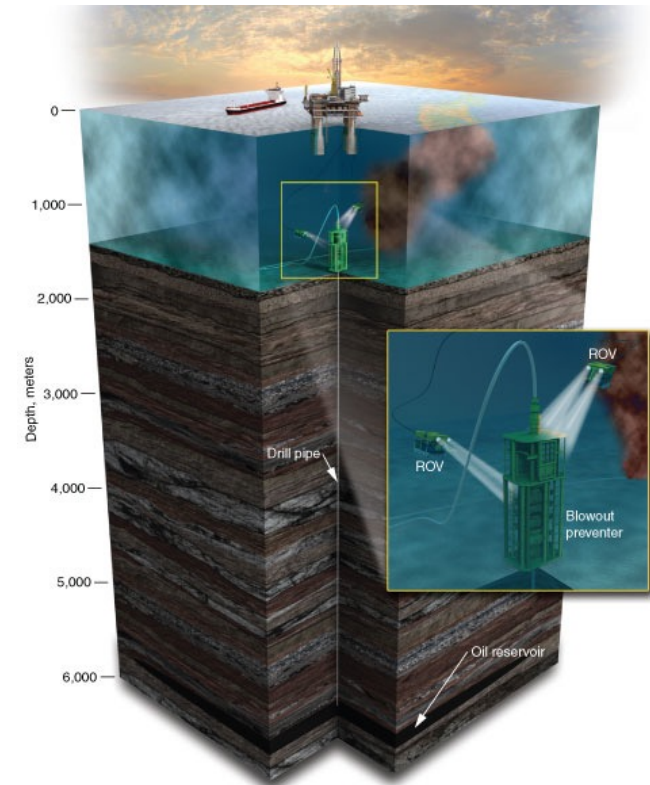
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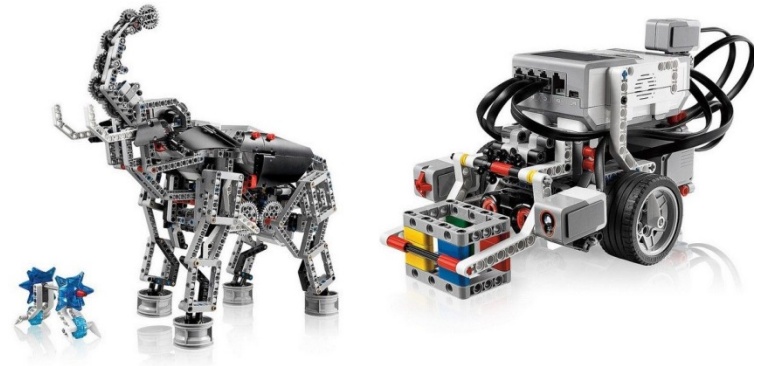
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# Present Everywhere

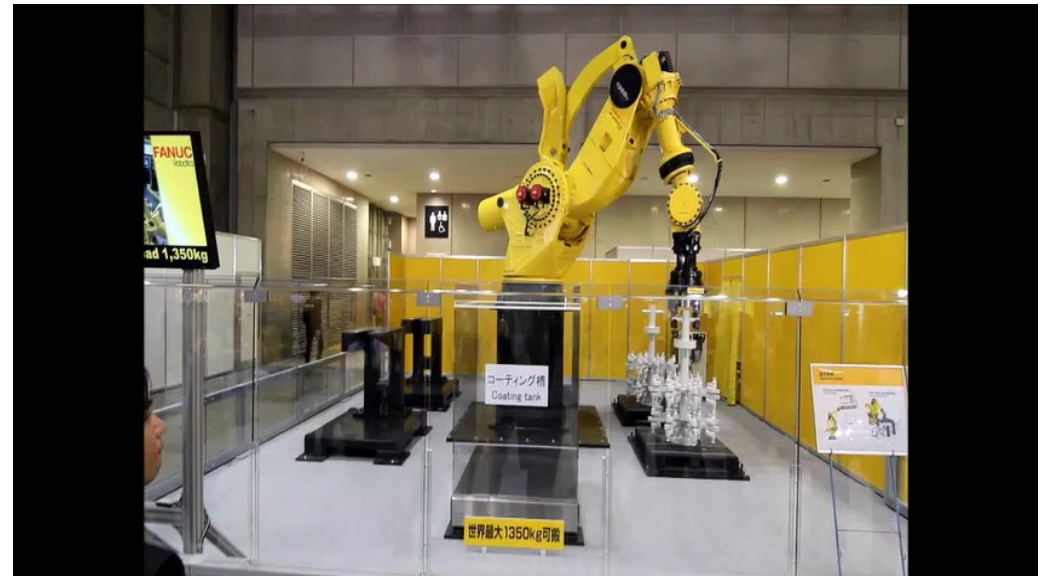
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Amazon bought Kiva for \$775M





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# Robotic technology becomes affordable

**TurtleBot 2**



**AR.DRONE**



**Kinect**



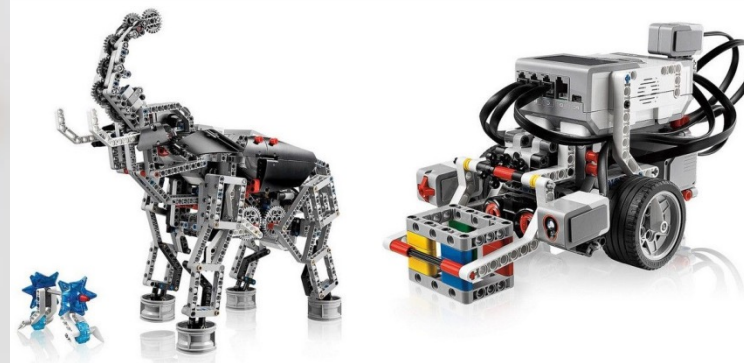
**IMU**



**Raspberry Pi**



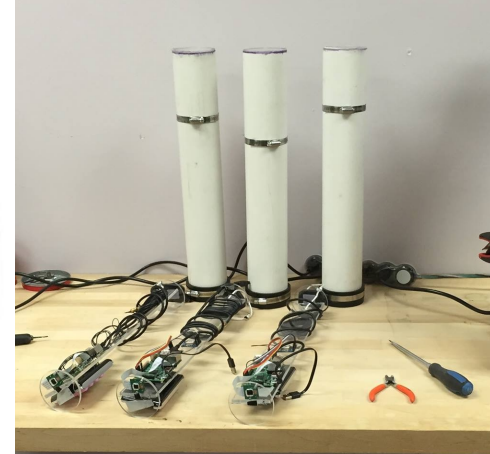
**GPS**



**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

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**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

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





# How to do poorly

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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

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- <http://www.cse.sc.edu/~yiannisr/>
- <http://www.cse.sc.edu/~yiannisr/574/2023Spring/>
- **Email:** [yiannisr@cse.sc.edu](mailto:yiannisr@cse.sc.edu)
  
- **Office hours:** 2235– Mon/Wed 13:00-14:10  
and by appointment



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**Develop  
algorithms for  
robotic  
applications**

**Philosophy**

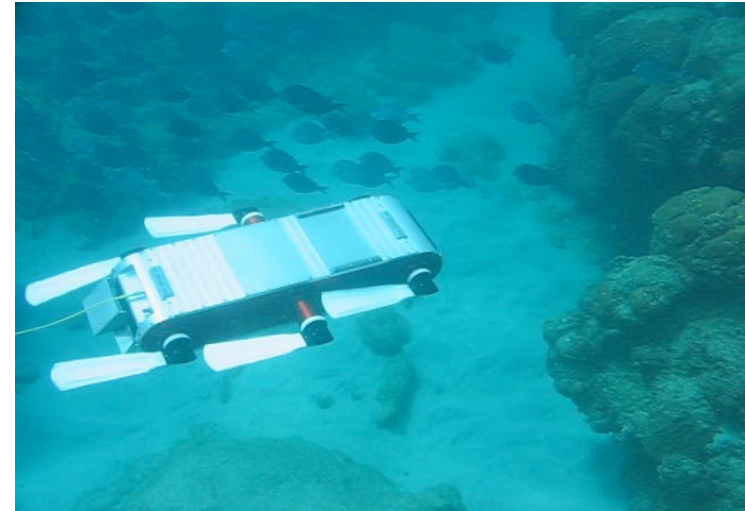
**Evaluate performance  
of the deployed robots**

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



# Recent Funding:

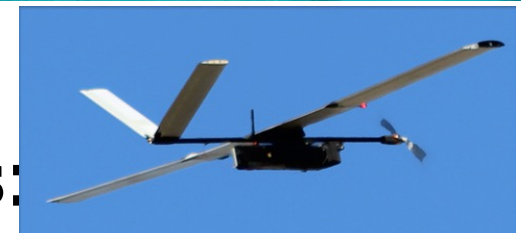
- **NSF CRI II-New:** Acquisition of a Heterogeneous Team of Field Robots for Coastal Environments
- **PI: I. Rekleitis.**
- **CoPIs:** J. Beer, J. O’Kane



Several **Surface Vehicles** 2 Aqua  
u/w  
vehicles

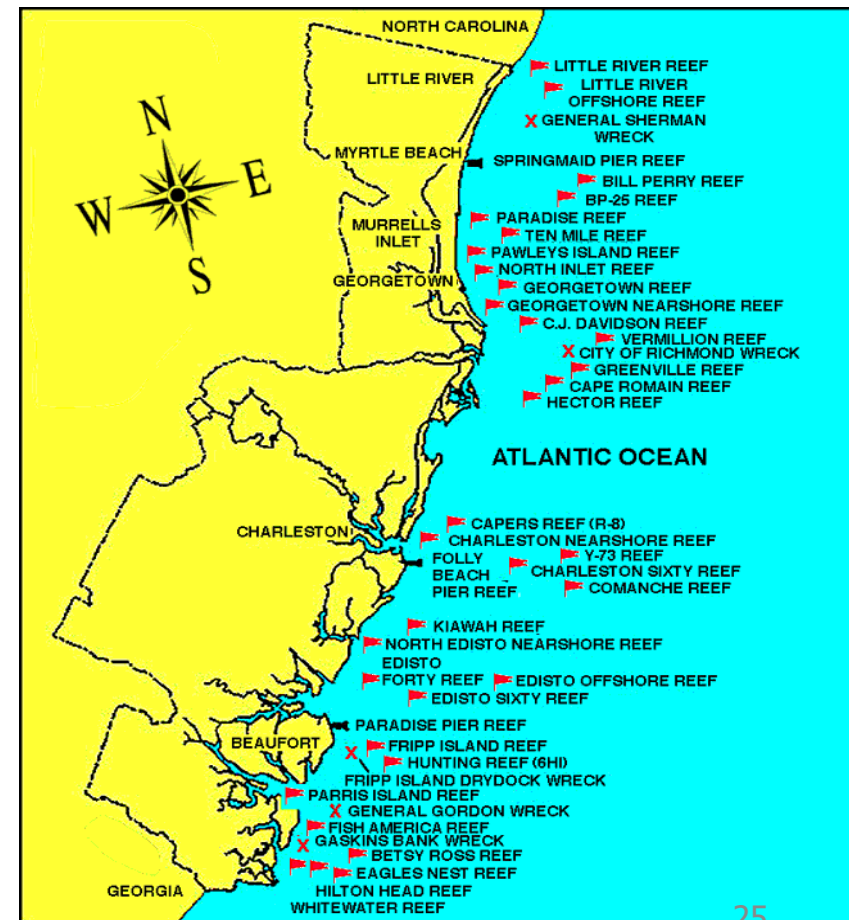
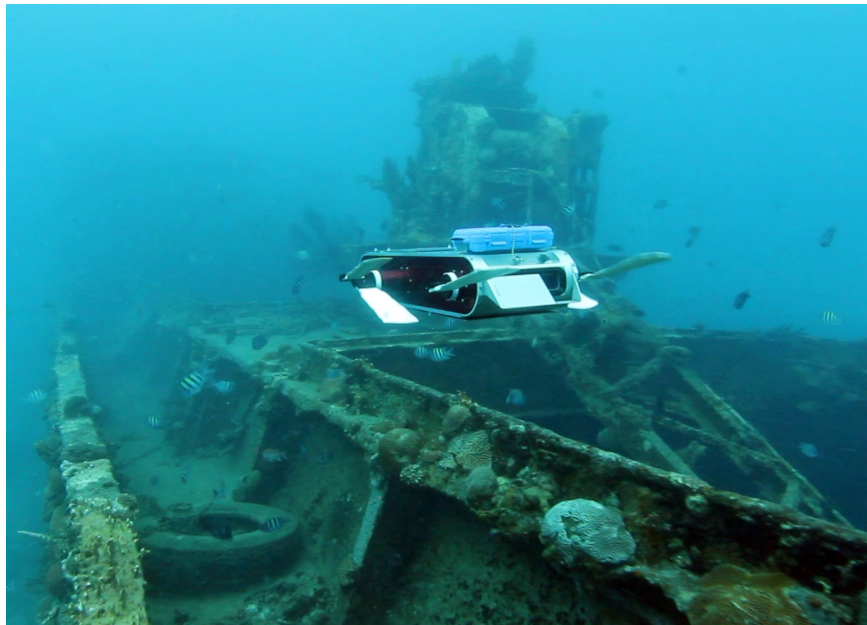


**Aerial Vehicles:**  
2 fixed wings  
2 quadrotor



# Recent Funding:

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

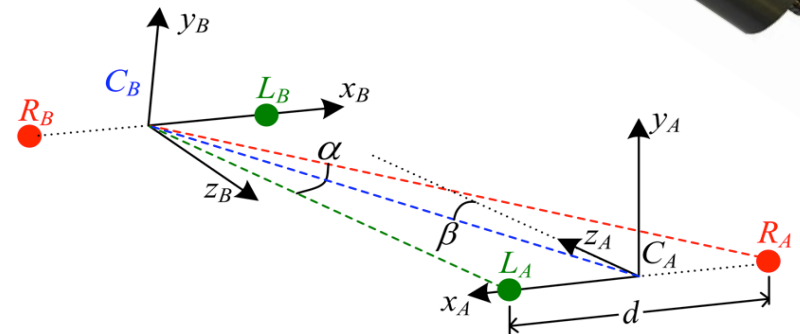




# Recent Funding:

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

## Stereo Based 3D Reconstruction



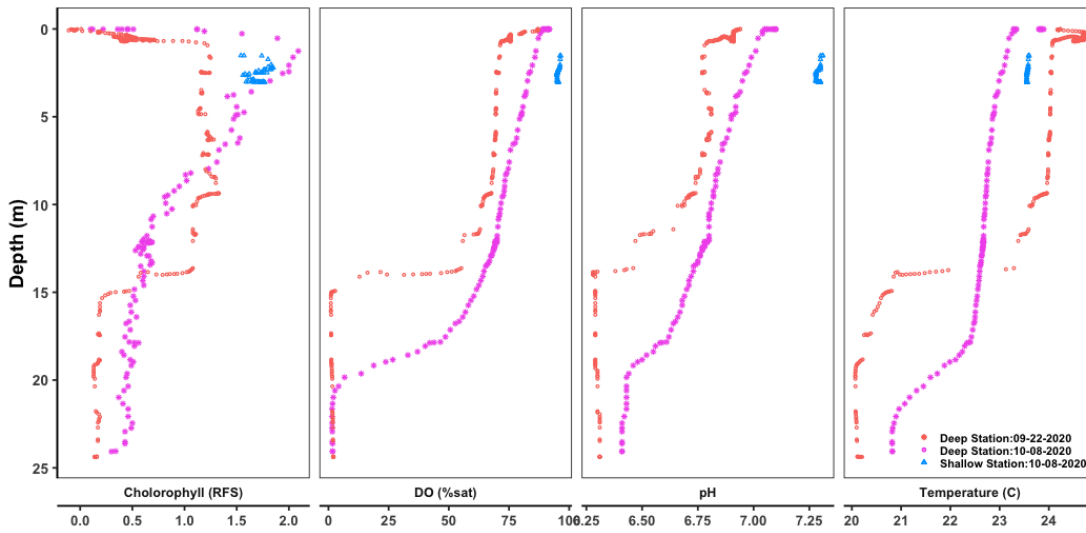
## Cooperative Localization



# Recent Funding:

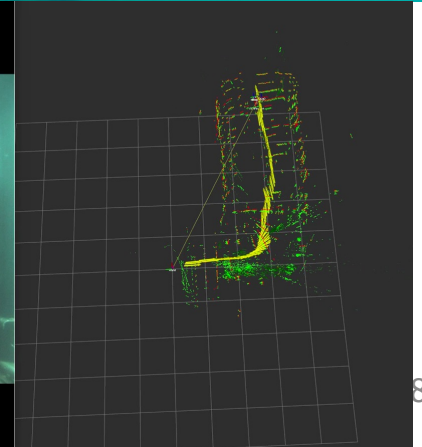
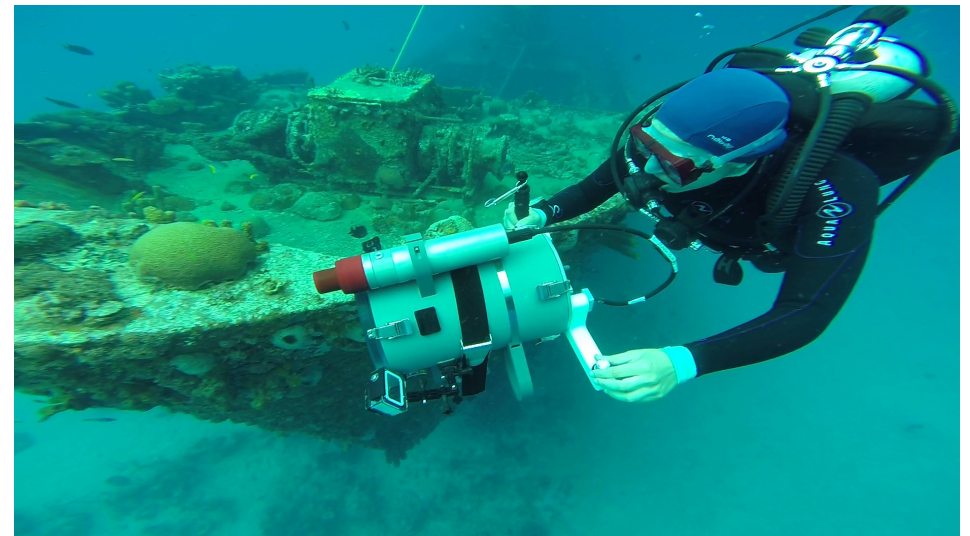


- **NSF RII Track-2 FEC:** Computational methods and autonomous robotics systems for modeling and predicting harmful cyanobacterial blooms.
- **Funding:** 2019-2023



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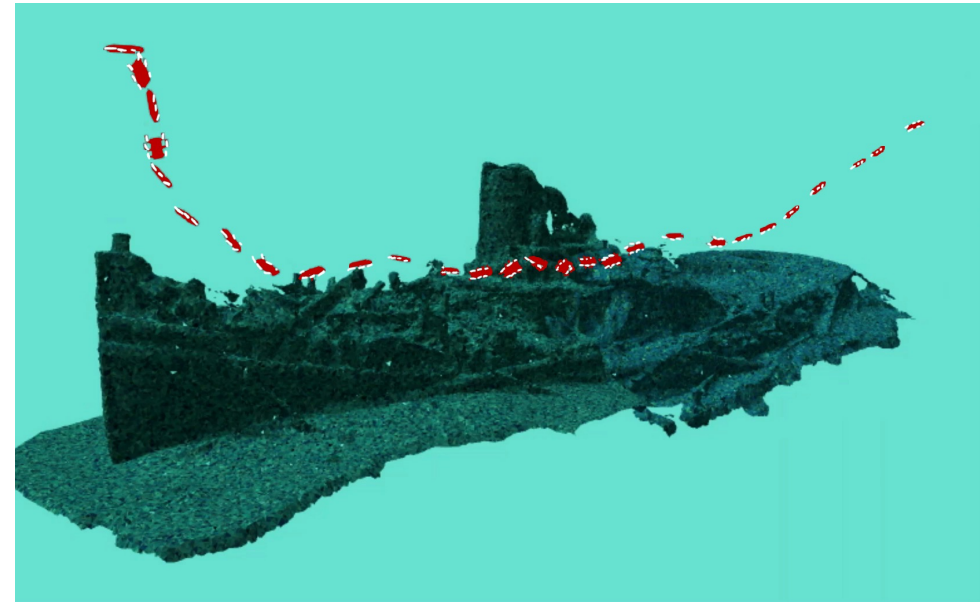
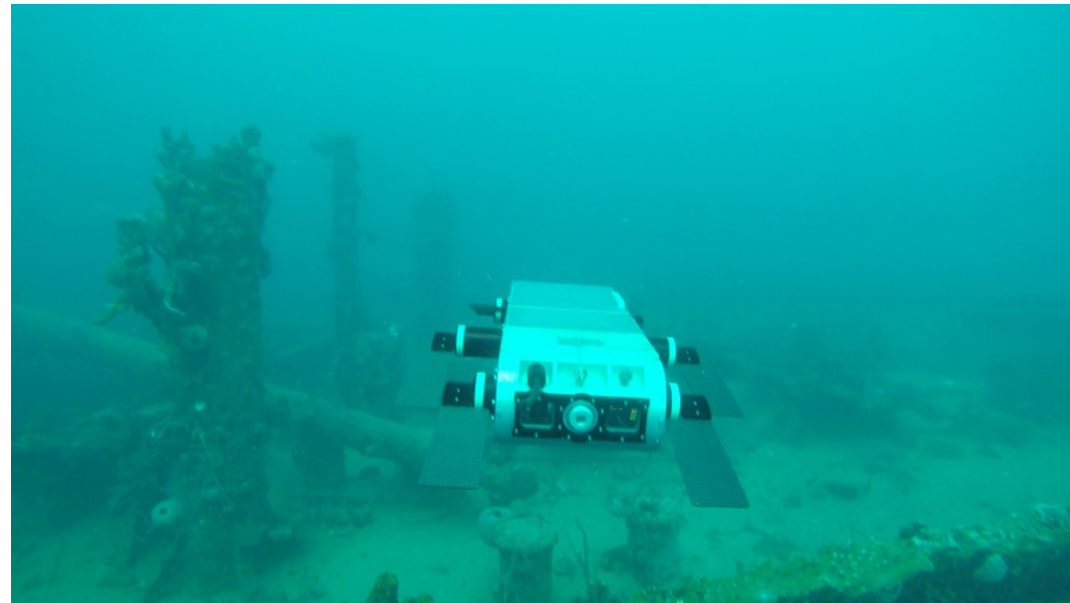
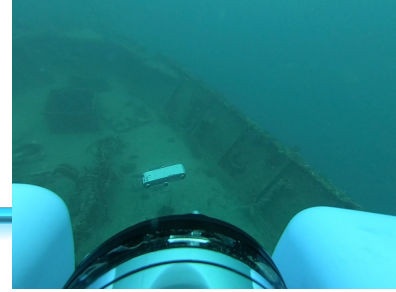
- **NSF CAREER:** Enabling Autonomy via Enhanced Situational Awareness for Underwater Robotics
- **Funding:** 2020-2025



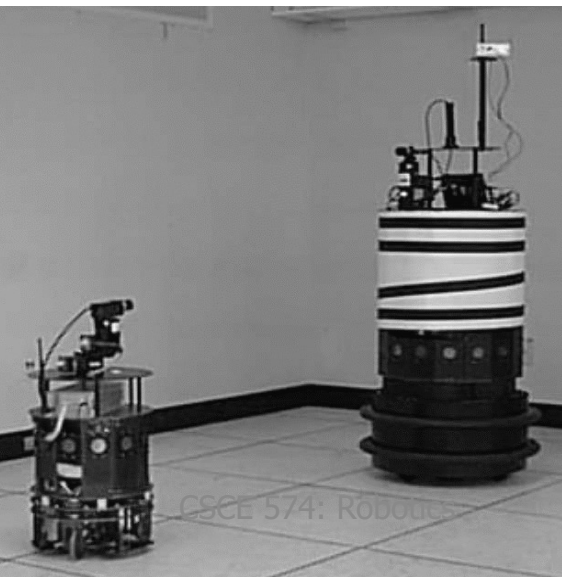
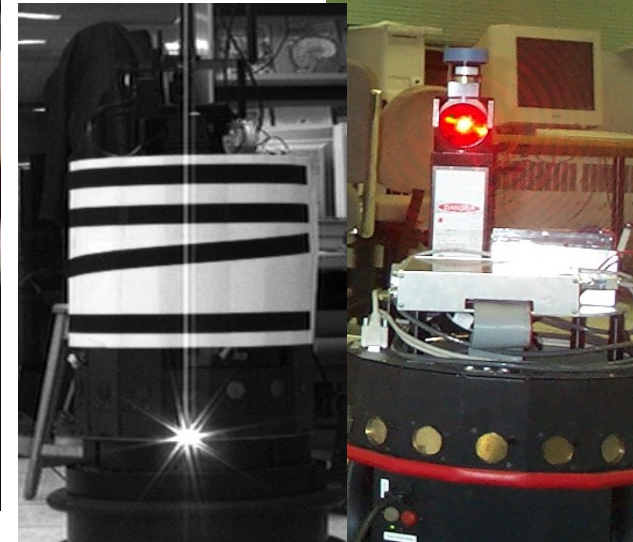
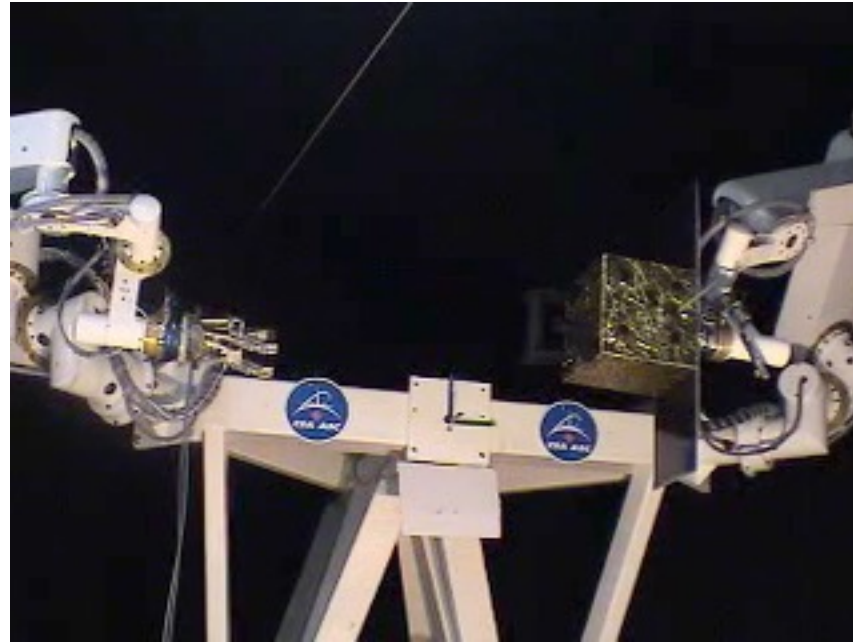


# Recent Funding:

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

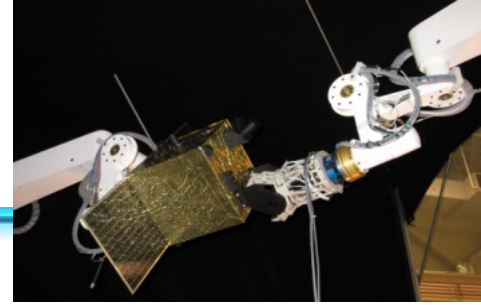


# Past Projects





# Past Projects



**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

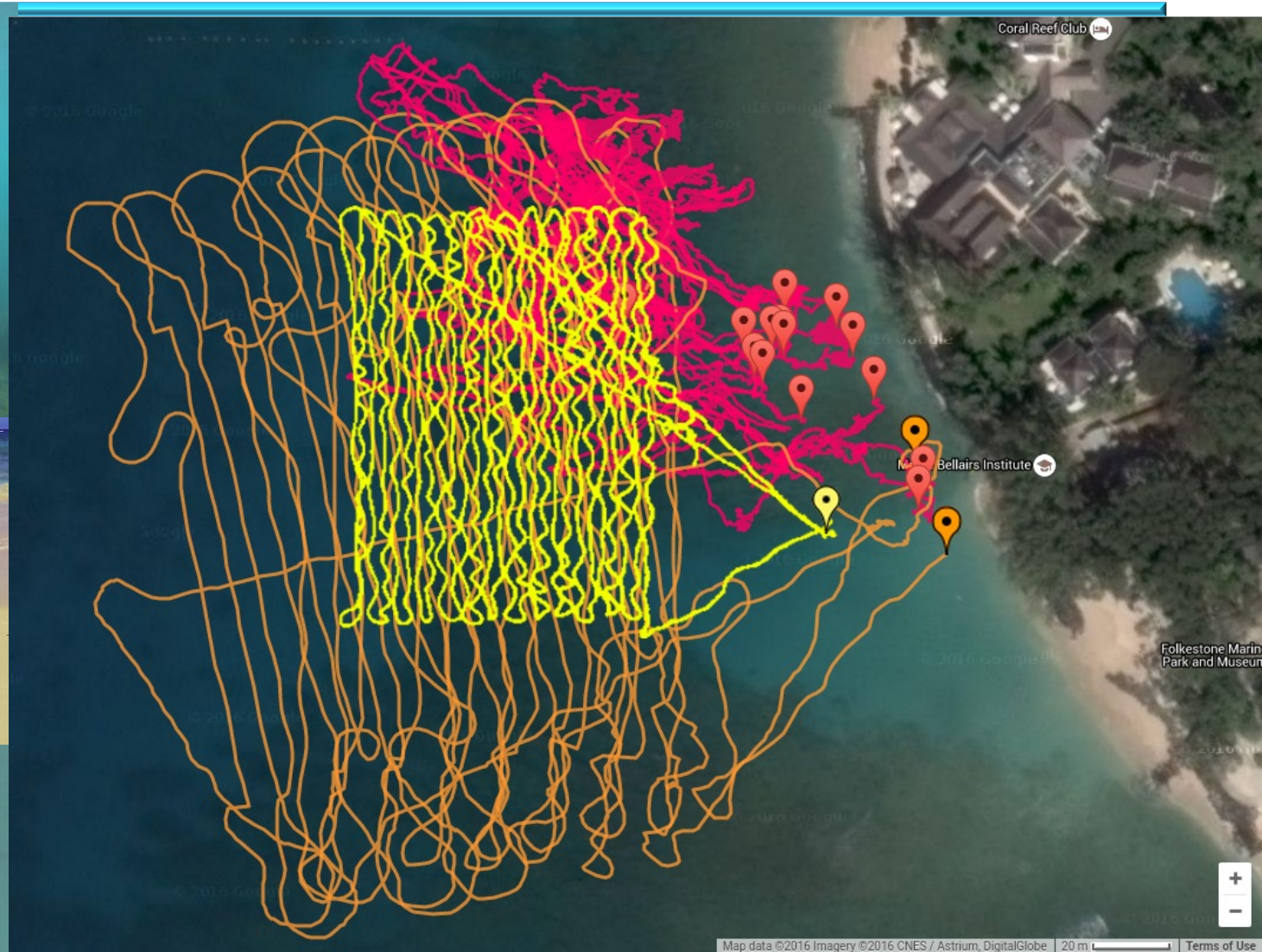
## Cooperative Localization

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





# Coral Reef Monitoring by Heterogeneous Robots

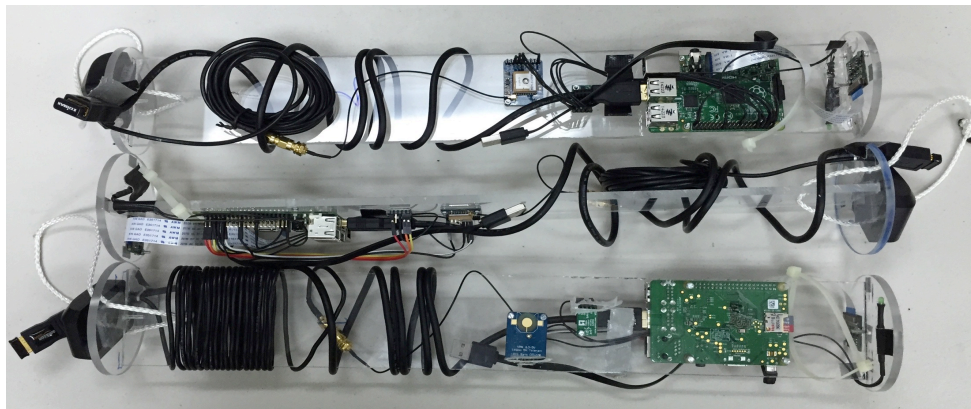




# Marine Robotics

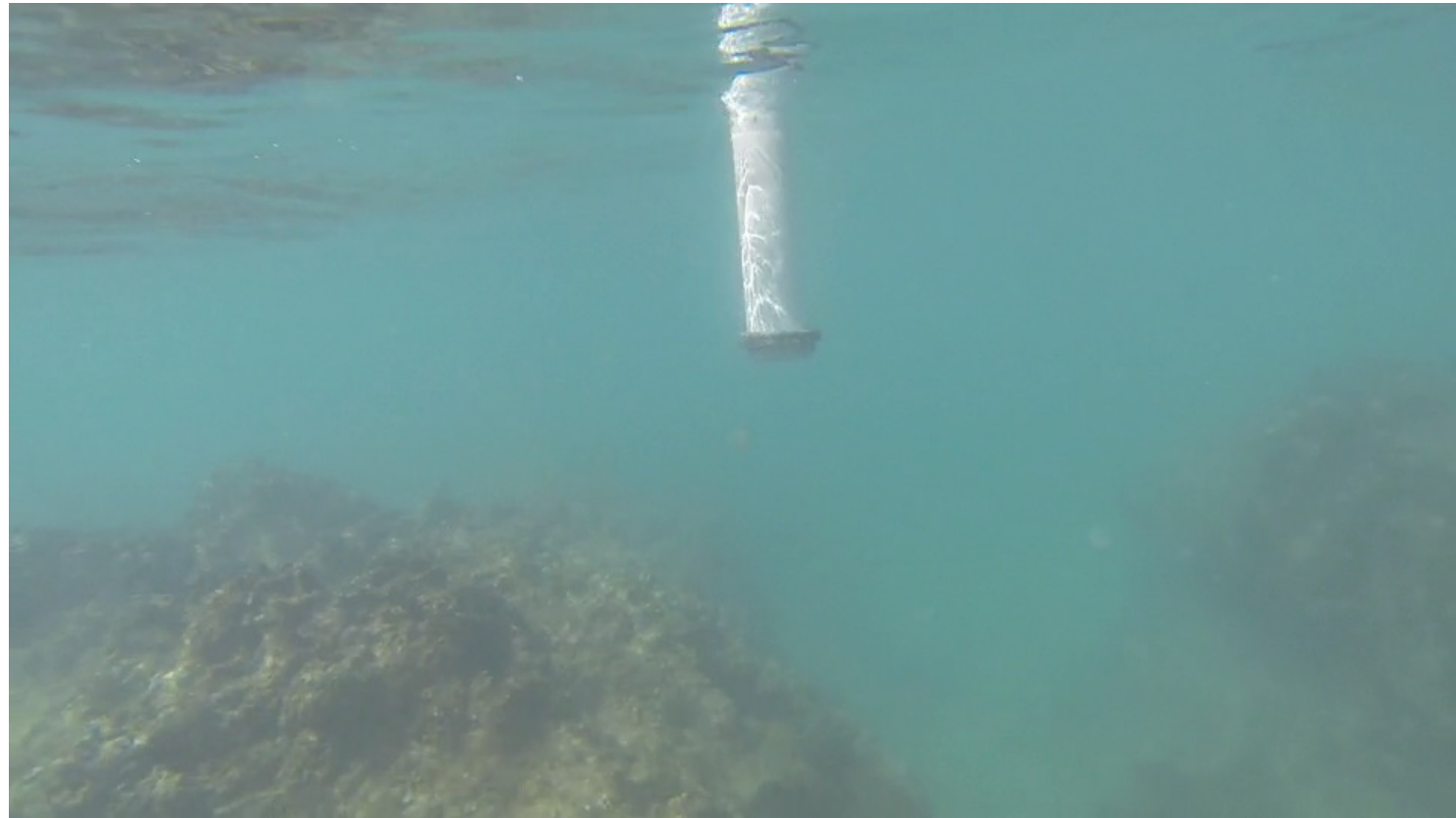
## Capstone Project: Drift Nodes

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



# Marine Robotics: Drift Nodes

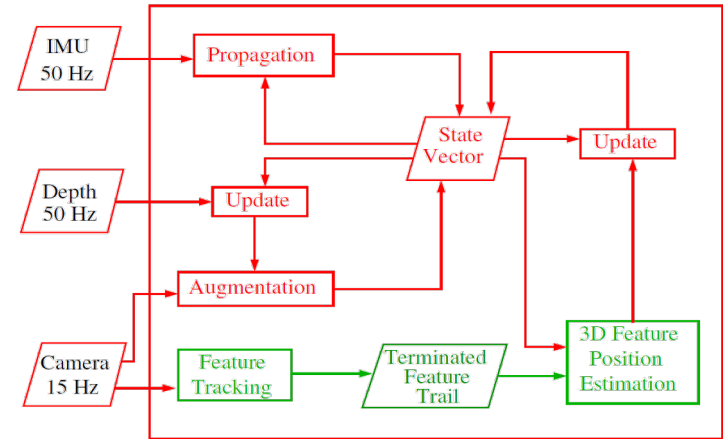
- Monitor, shallow coral reefs.
- Improve estimation accuracy



# Marine Robotics

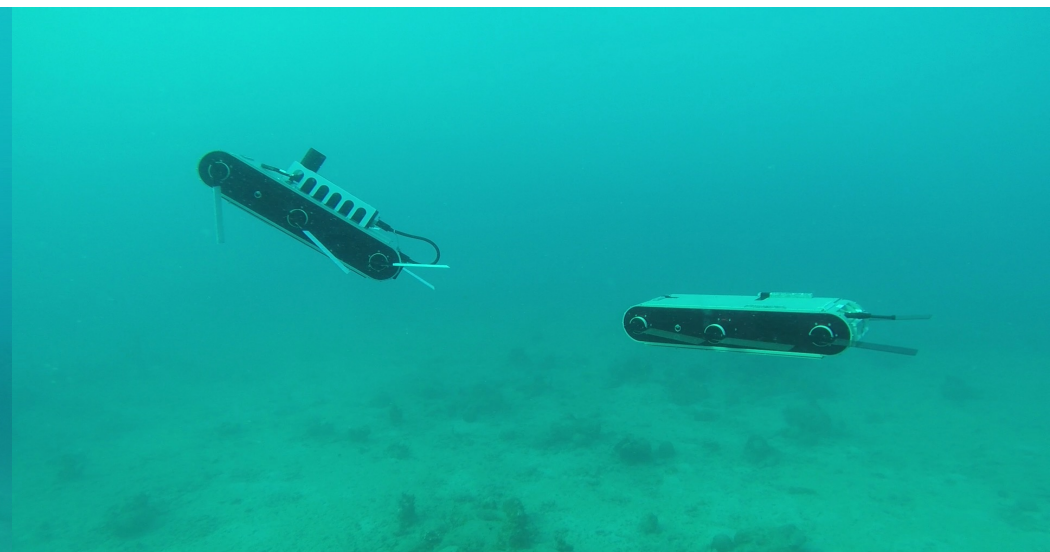
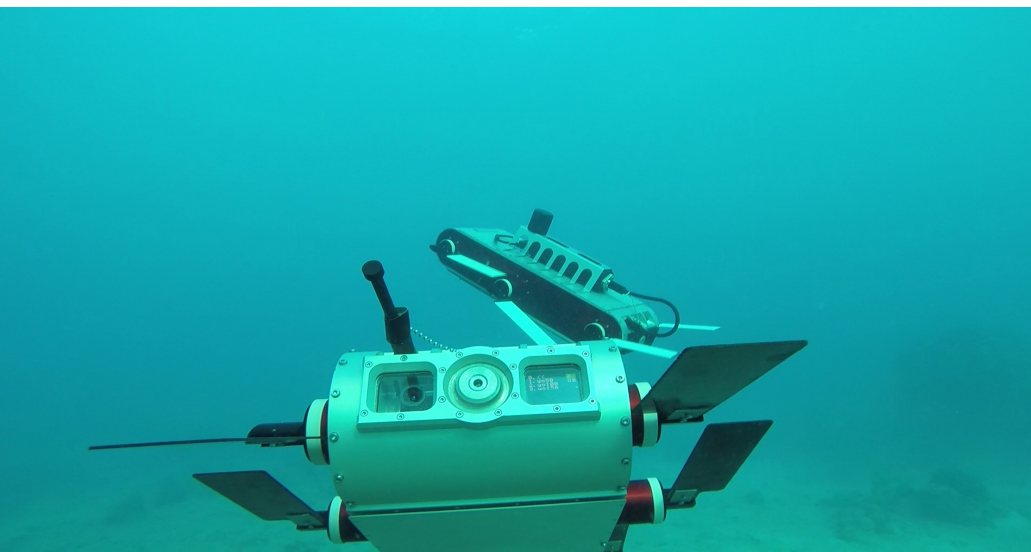
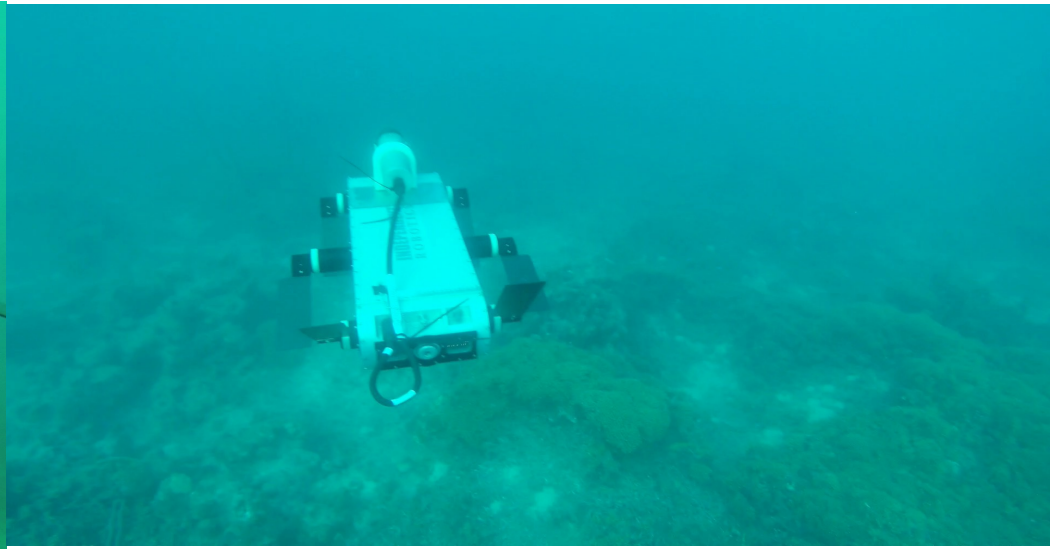
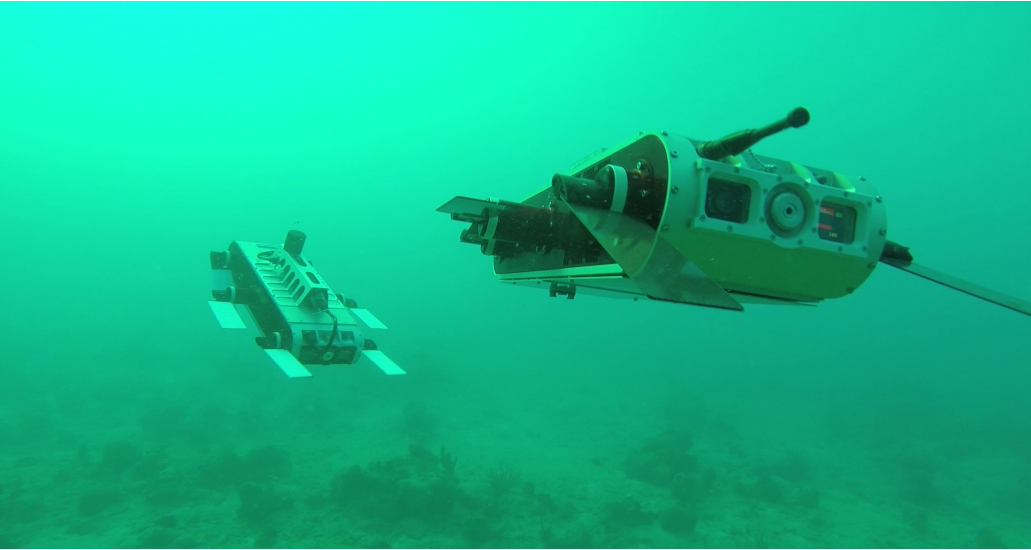
## Underwater Situational Awareness

- Vision-INS State Estimation
- Path Planning
- Mapping



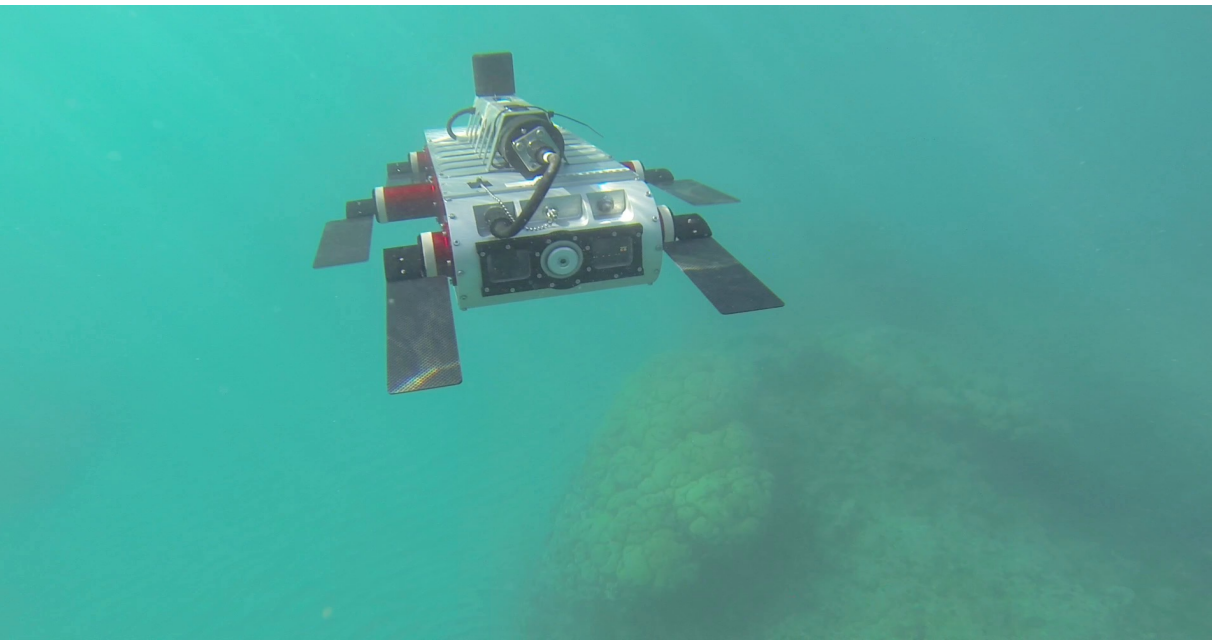


# Marine Robotics



# Vehicles

- Two Aqua with USBL





# Vehicles

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- Six ASVs



# Vehicles

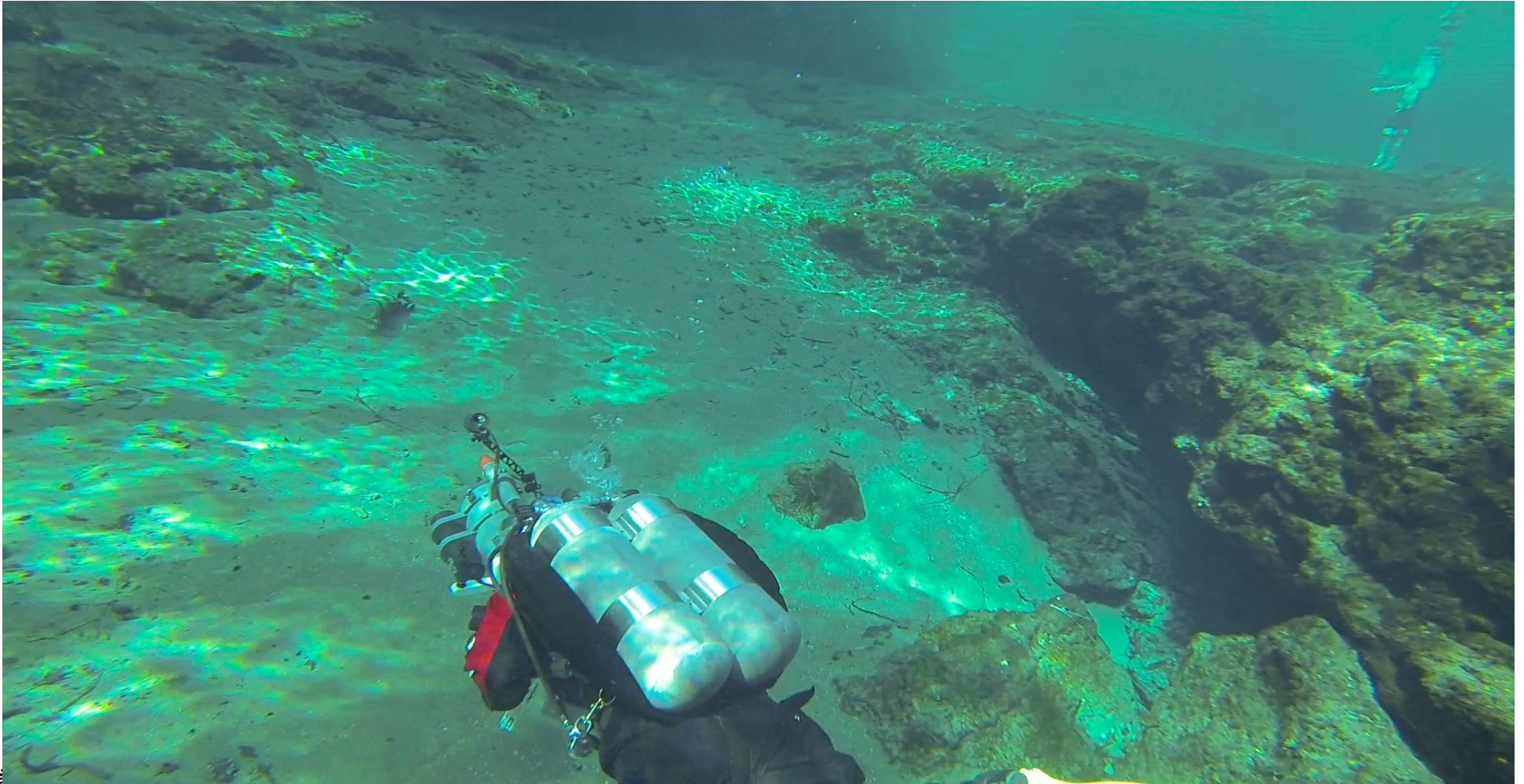
- Drones





# Sensors

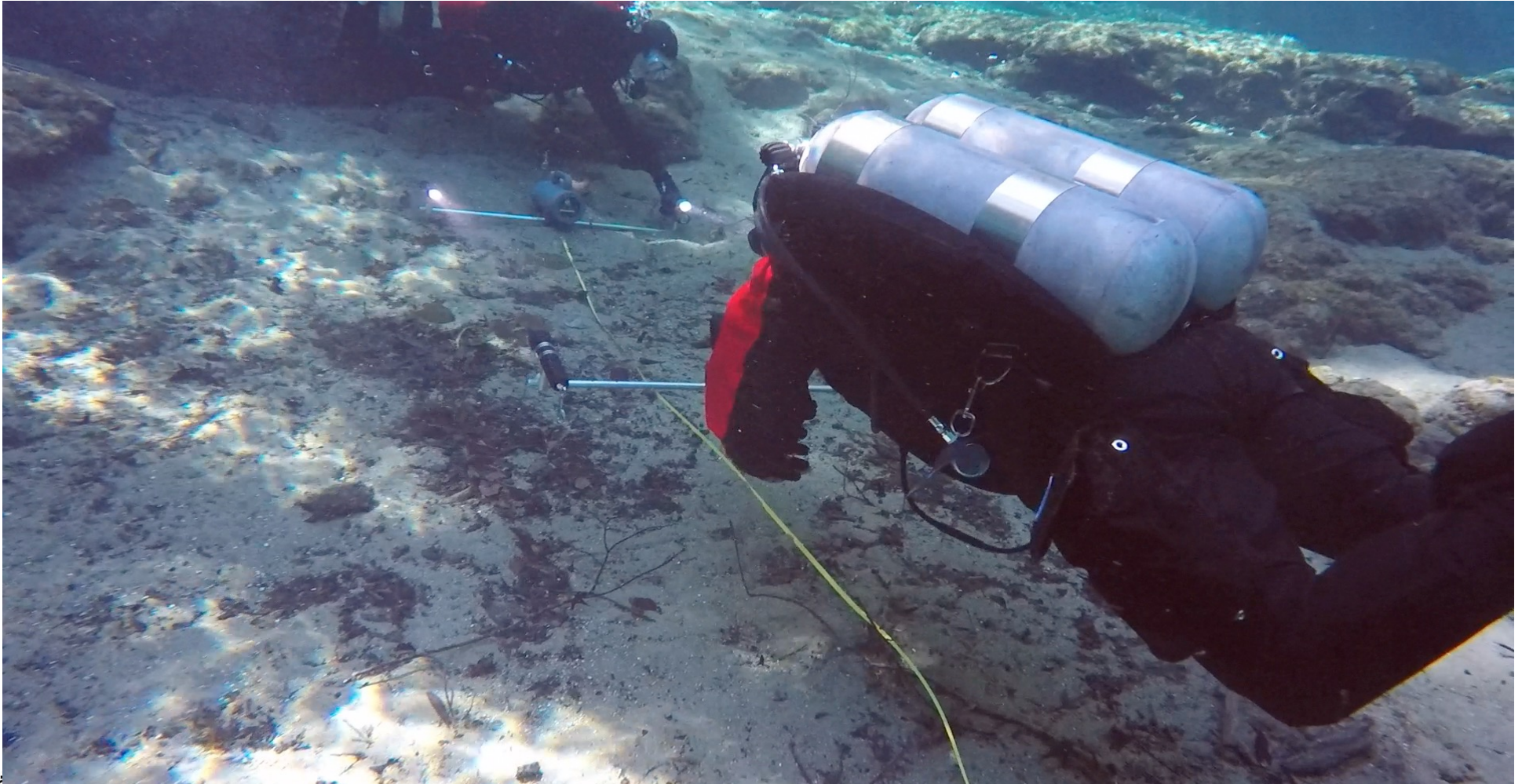
- Stereo Rig – 2017 (made at SC)





# Sensors

- Cooperative Localization (made at SC)



# Shipwreck Mapping

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# Shipwreck Mapping

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Robot's Eye View



# Underwater Cave Mapping

An underwater scene showing a cave interior. The walls are covered in stalactites and other rock formations. The water is dark blue, and the lighting is dim, creating a mysterious atmosphere. The text "Cave Mapping using Stereo Vision" is overlaid in the center.

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

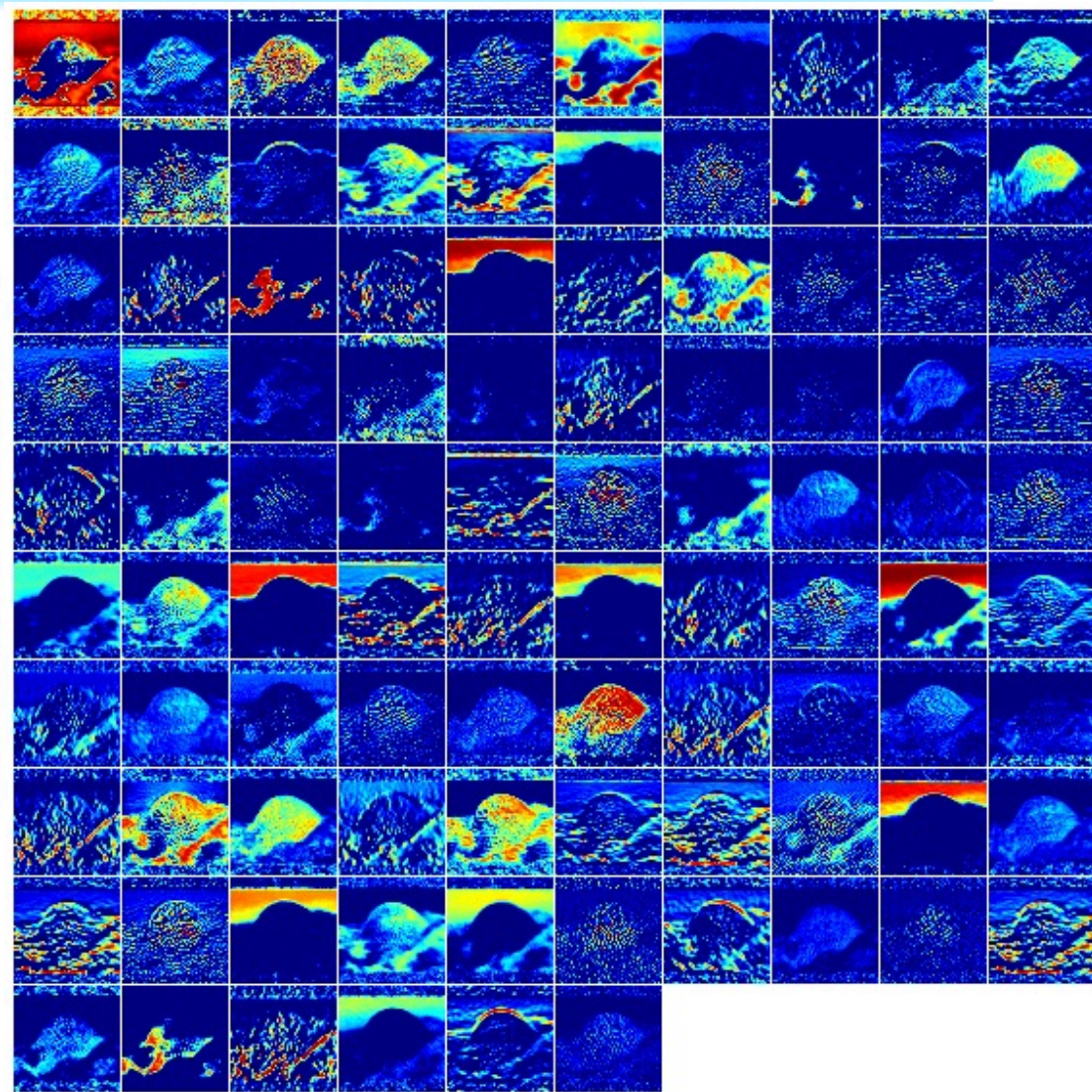
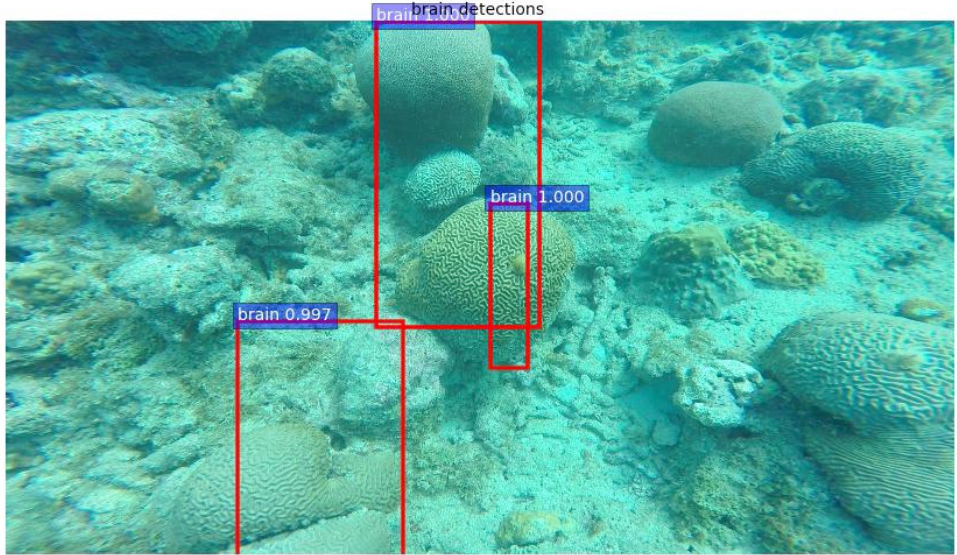
**Sharmin Rahman, Alberto Quattrini Li, and Ioannis Rekleitis**





# 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:

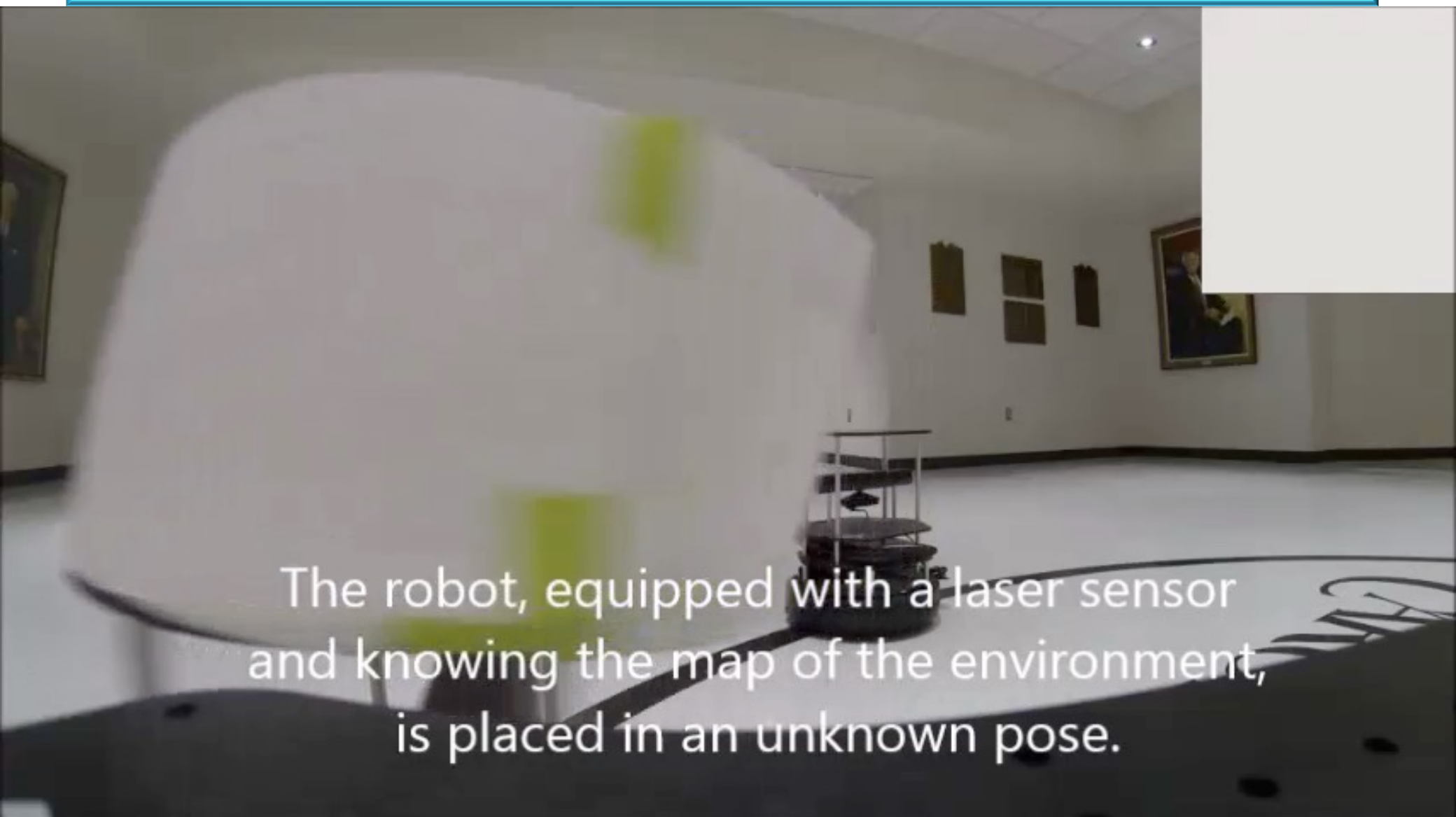
HRI with limited bandwidth



Instructing Aqua with tags

# Indoor: Localization with dynamic obstacles

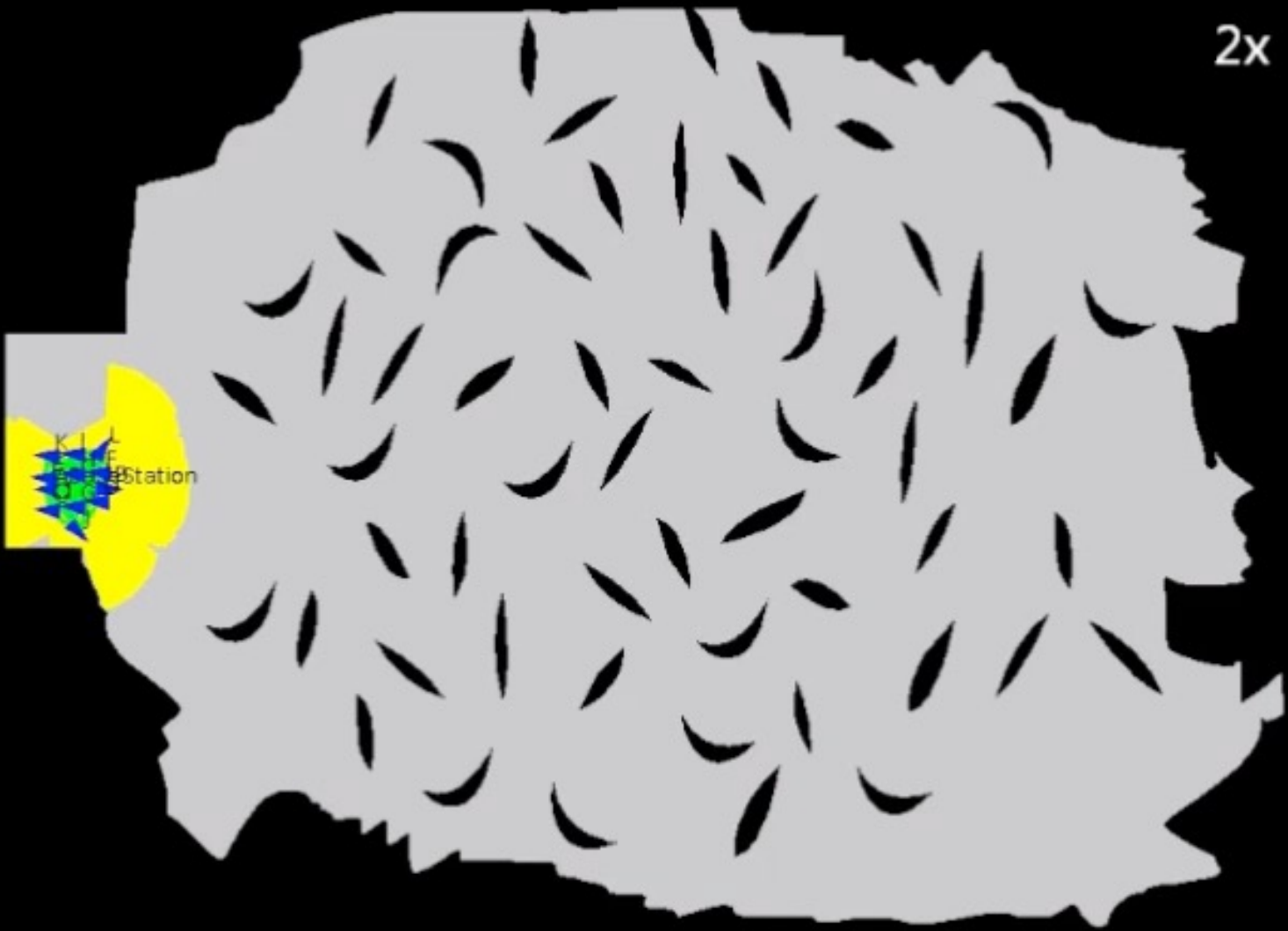
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A mobile robot is positioned in a hallway. A large, white, irregularly shaped object is in the foreground, partially obscuring the view. The robot is a small, dark, cylindrical device with a metal frame on top. The hallway has white walls, a dark baseboard, 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

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# Underwater Navigation

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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

