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

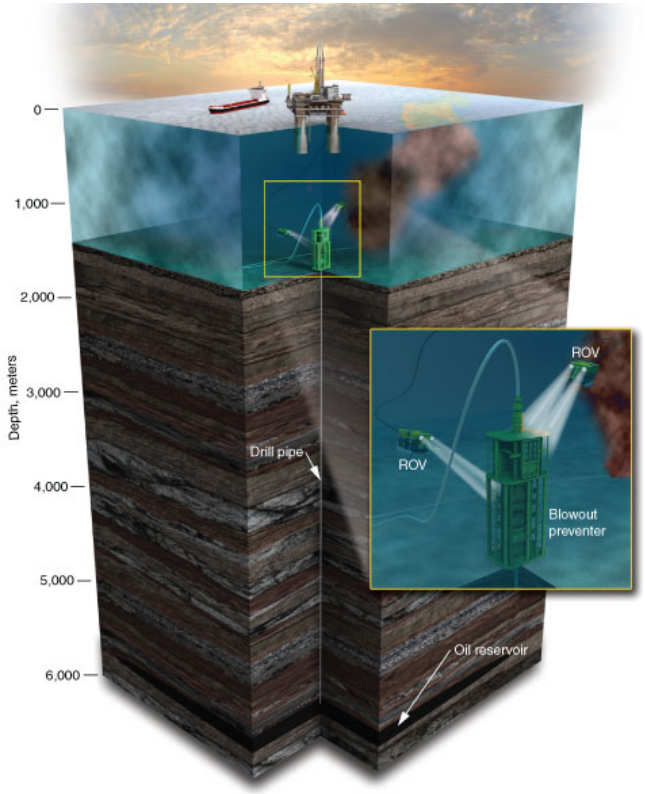
- At home
- On the road
- **In the sky (drones)**
- In the fields
  (agricultural robotics)
- In resource utilization
  (ROV in the oil industry)
- Along power lines
- In Hospitals
- Education
- In Factories
- In Warehouses
- In Space

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

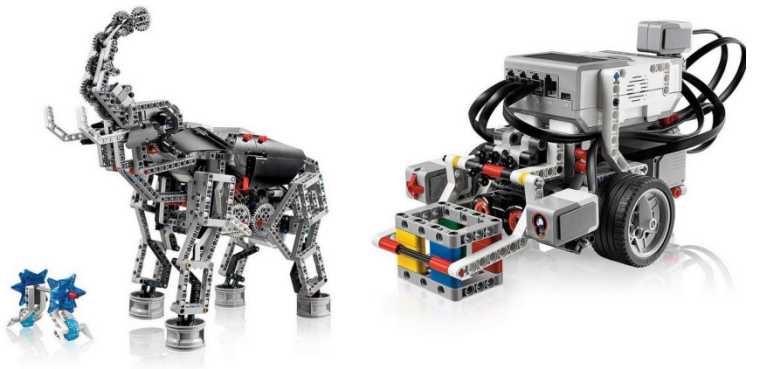
- At home
- On the road
- In the sky (drones)
- In the fields
  (agricultural robotics)
- In resource utilization
  (ROV in the oil industry)
- **Along power lines**
- In Hospitals
- Education
- In Factories
- In Warehouses
- In Space

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

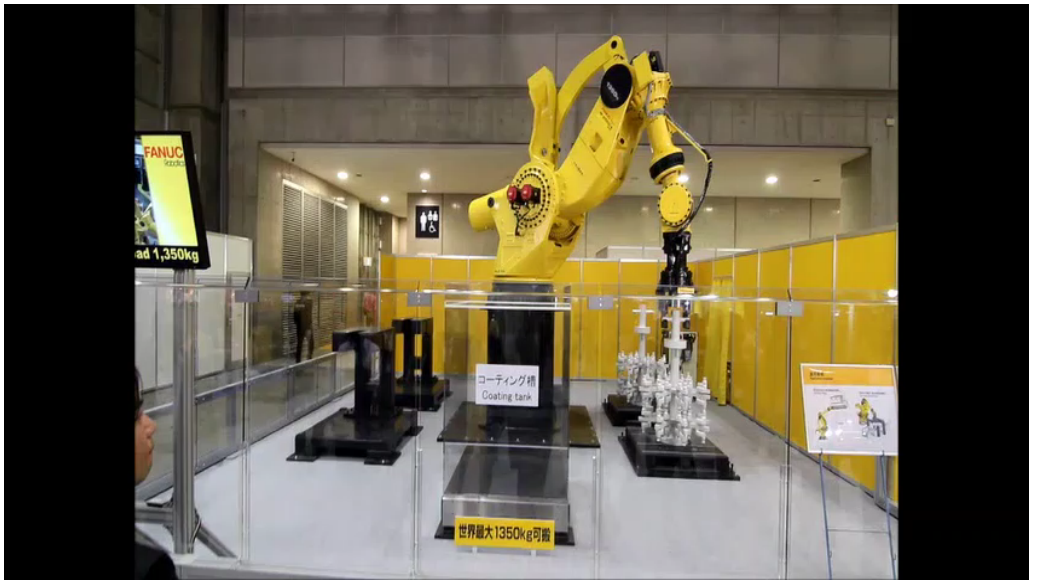
Present Everywhere

- 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

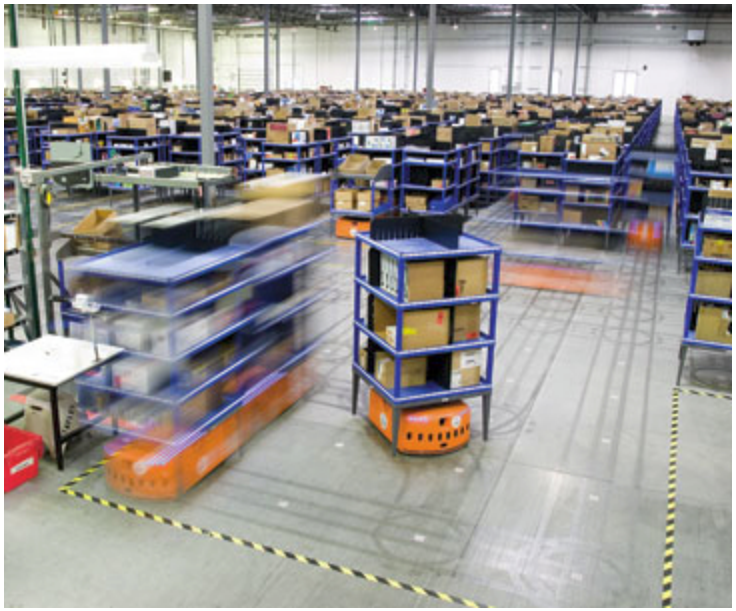
- At home
- On the road
- In the sky (drones)
- In the fields
  (agricultural robotics)
- In resource utilization
  (ROV in the oil industry)
- Along power lines
- In Hospitals
- Education
- **In Factories**
- In Warehouses
- In Space



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**

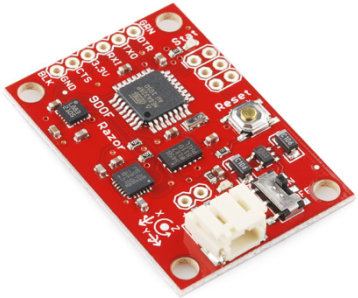
Robotic technology becomes affordable

TurtleBot 2

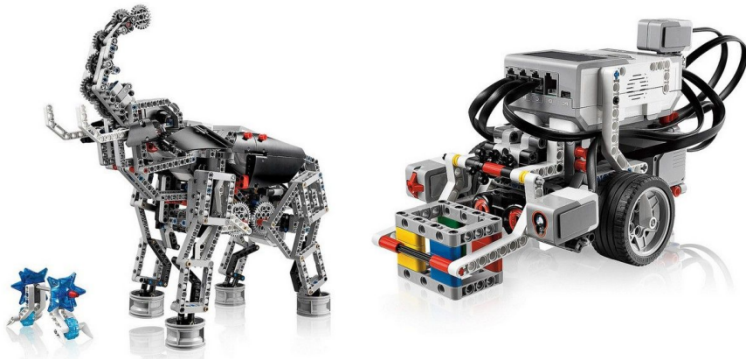
AR.DRONE

Kinect

IMU



Raspberry Pi

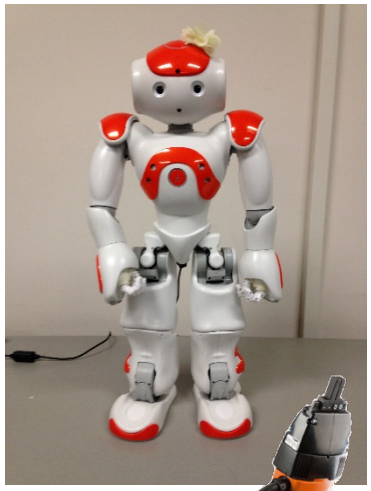


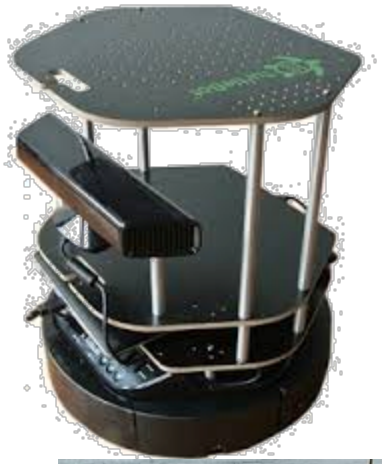
Lego Mindstorm

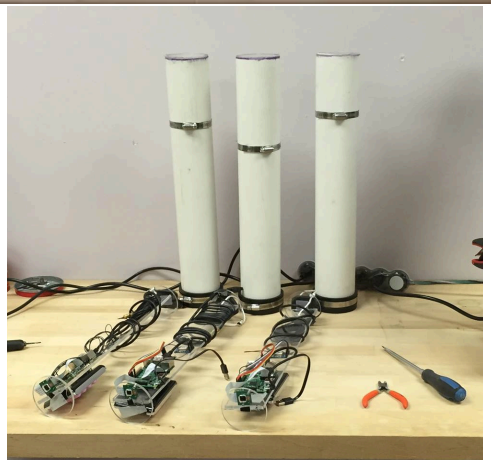
GPS

Robotics at USC

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

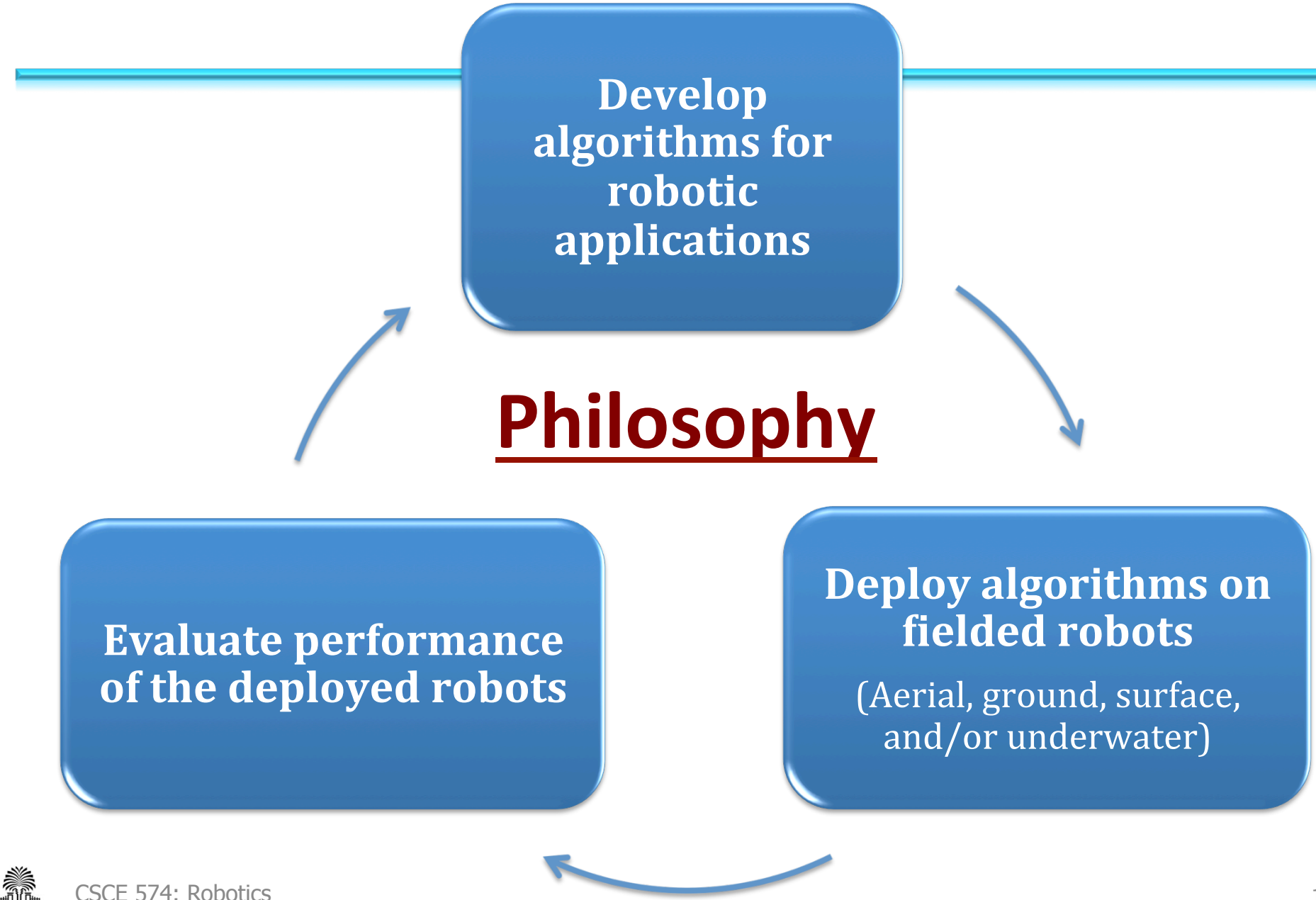






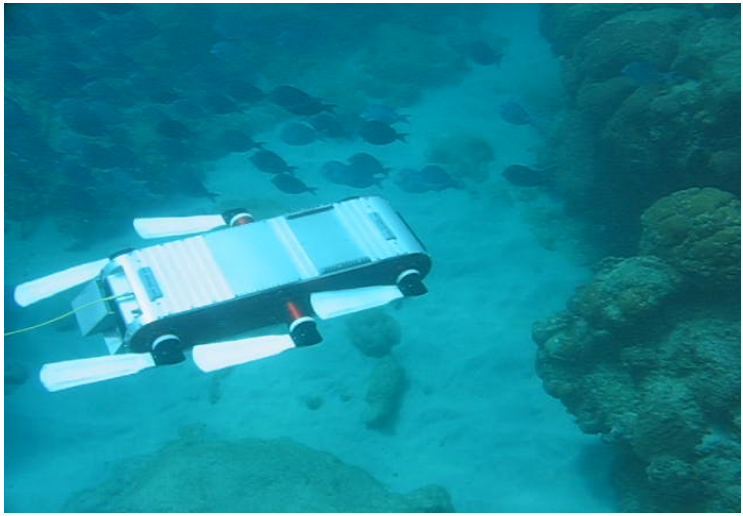
Autonomous Field Robotics Lab

Autonomous Field Robotics Lab


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

Recent Funding:

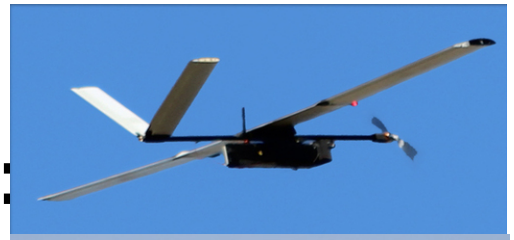
- **NSF CRI II-New**: Acquisition of a Heterogeneous Team of Field Robots for Coastal Environments
- **PI: I. Rekleitis.**
- CoPIs: J. Beer, J. O'Kane



Several **Surface Vehicles**

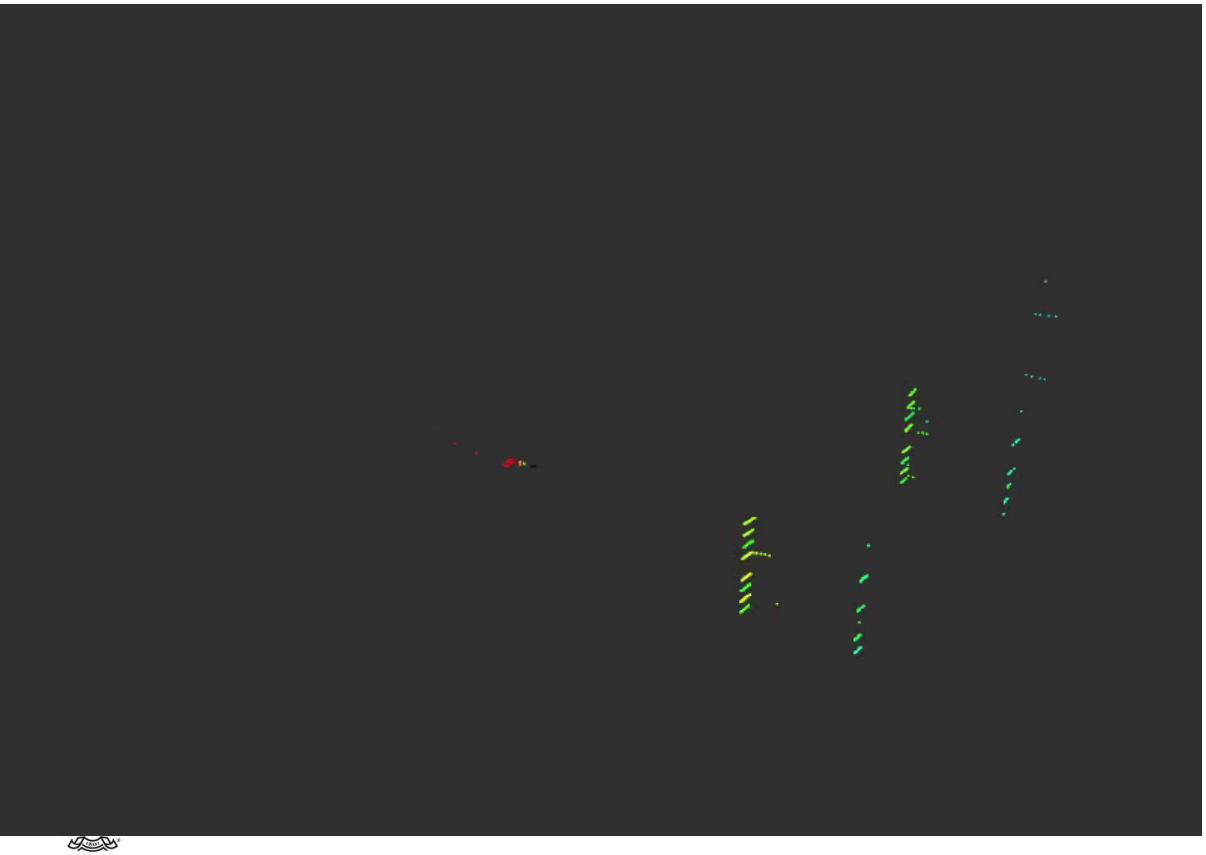
2 **Aqua** u/w vehicles

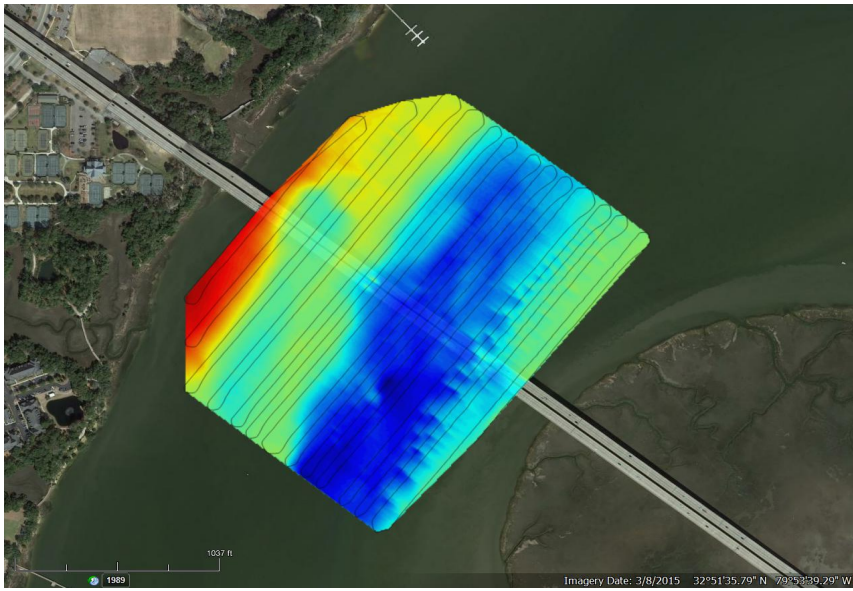
Aerial Vehicles:
2 fixed wings
2 quadrotor



Recent Funding:

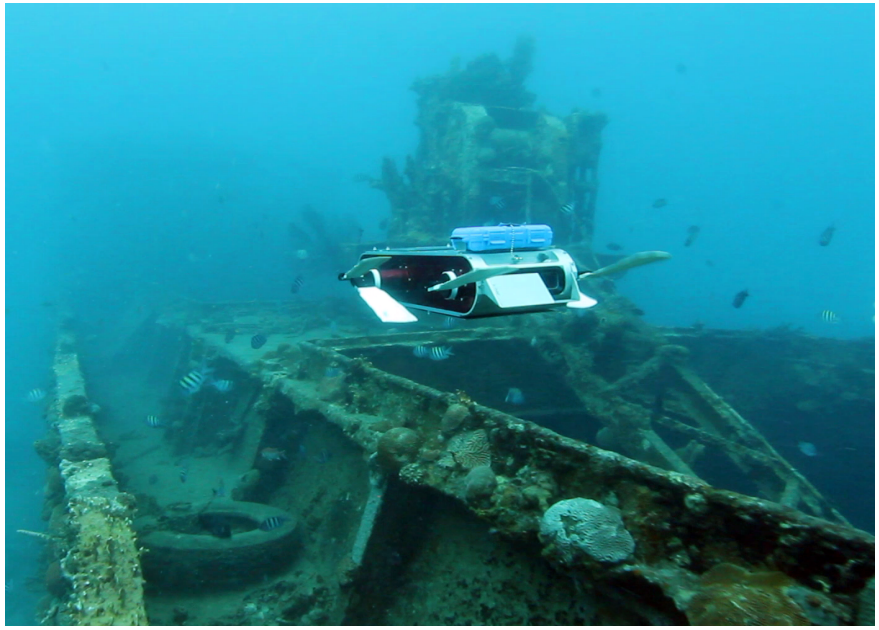
- **SC Floods Research Initiative:** Rapid Assessment of Bridge Scouring and Recovery Following Extreme Flood Events. **PI**: G. Voulgaris

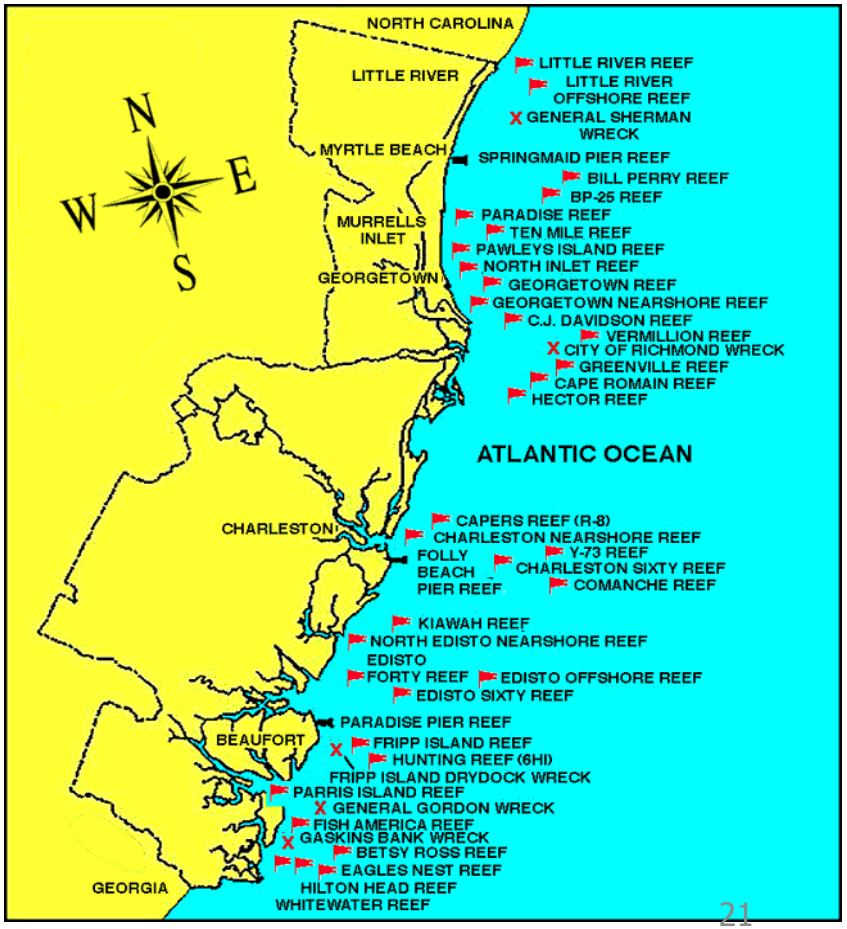




Recent Funding:

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



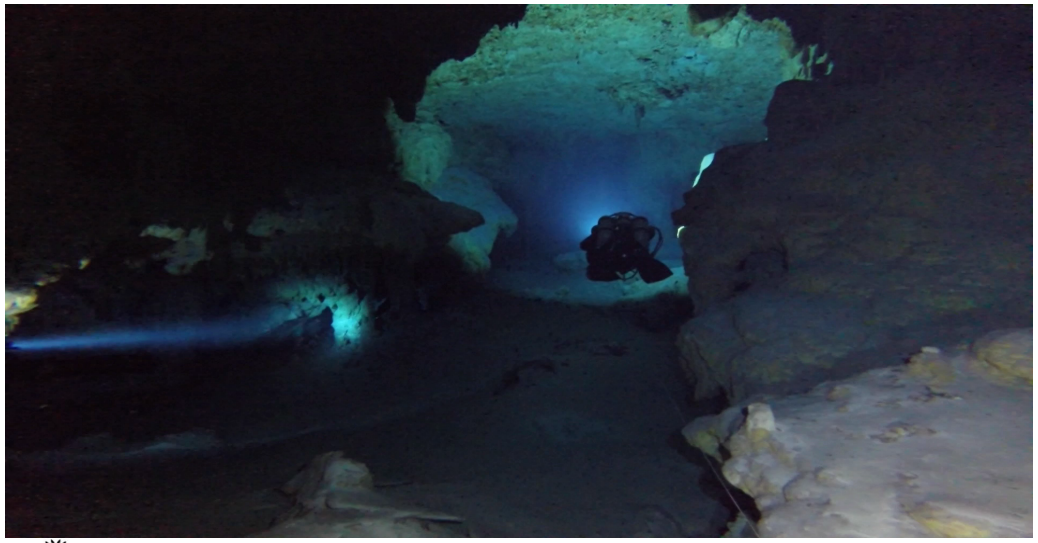


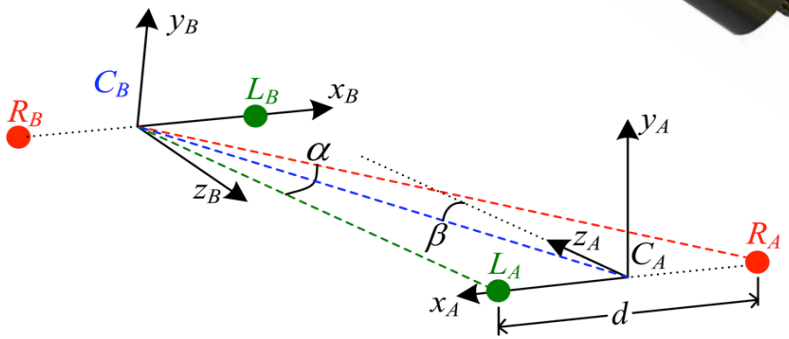
Recent Funding:

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

SONAR-Vision Fusion

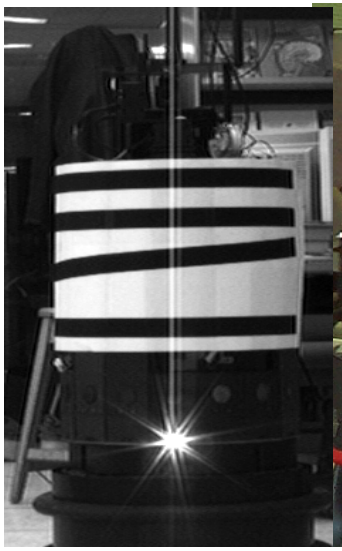
Stereo Based 3D Reconstruction

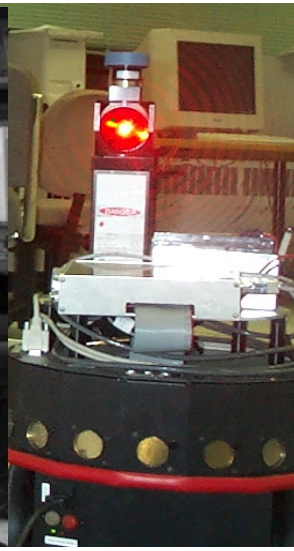


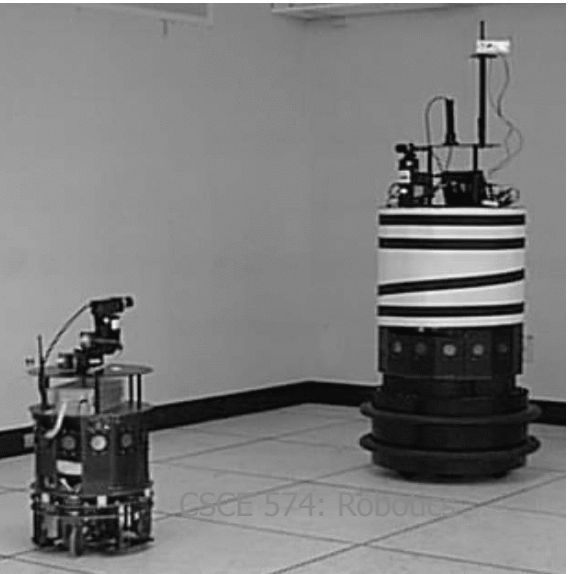


Cooperative Localization

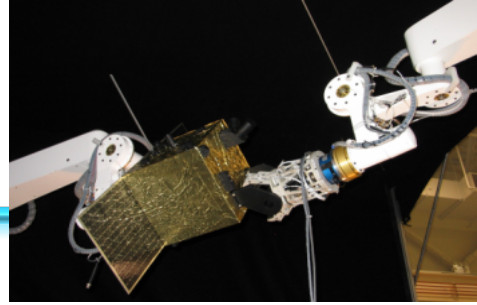
Past Projects







Past Projects



Complete Optimal Terrain Coverage using an Unmanned Aerial Vehicle

Anqi Xu
Chatavut Viriyasuthee
Ioannis Rekleitis

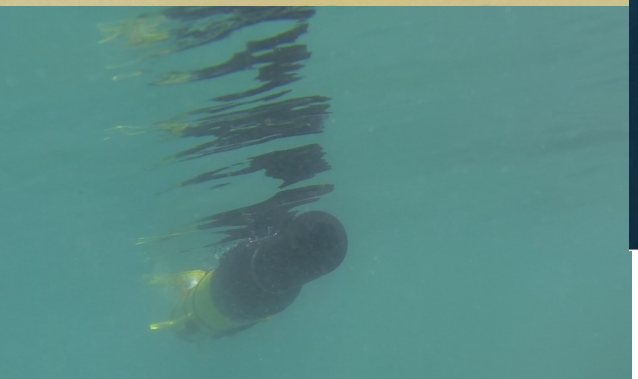
McGill

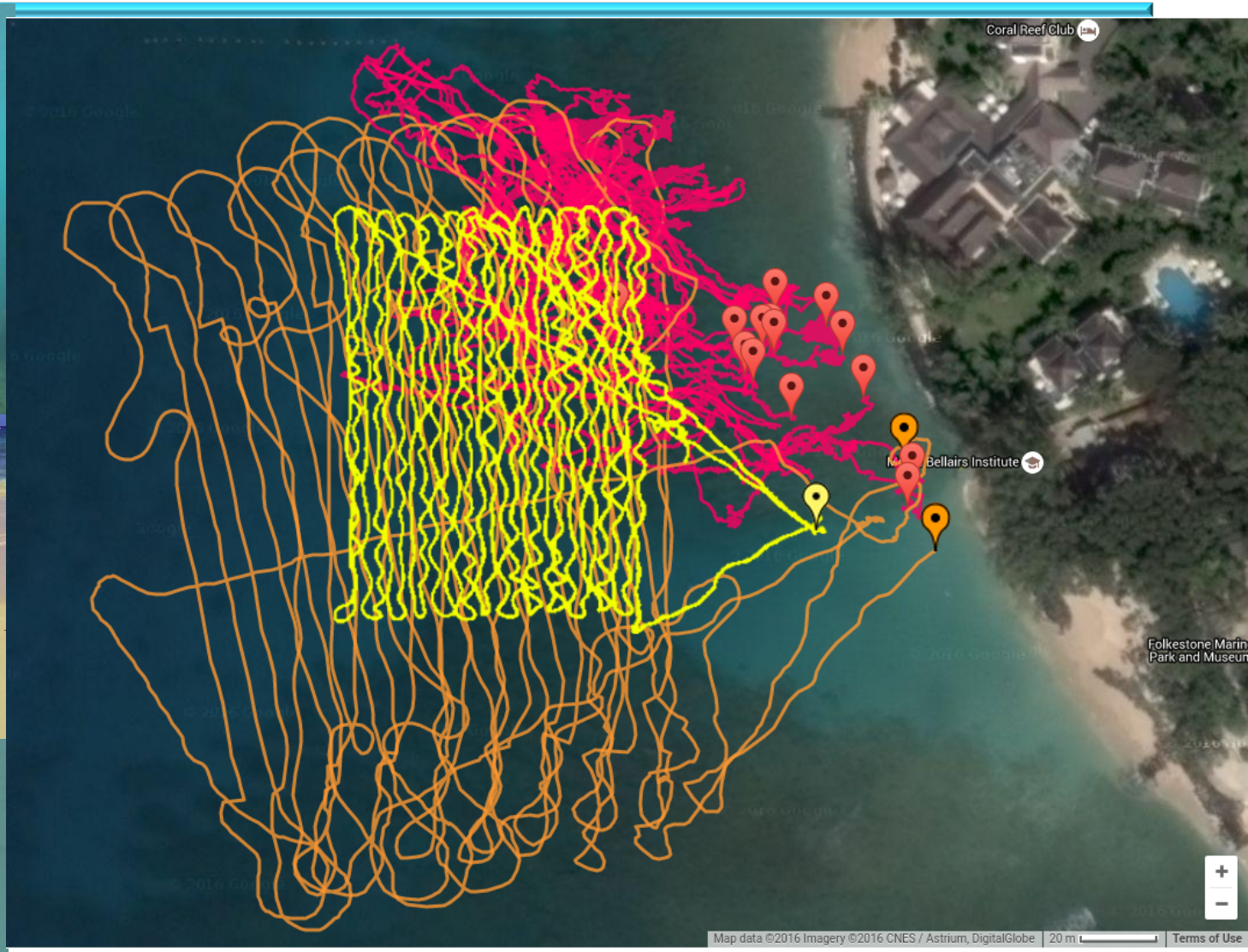
Aerial Robotics

Cooperative Localization

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

Coral Reef Monitoring by Heterogeneous Robots

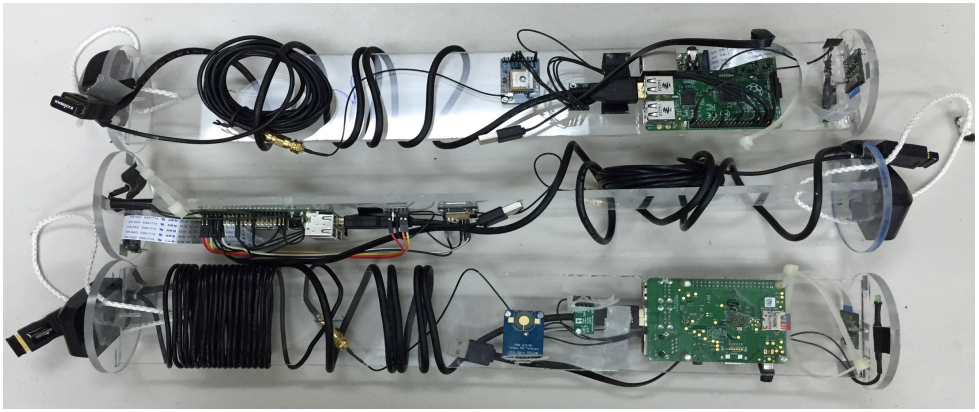




Marine Robotics

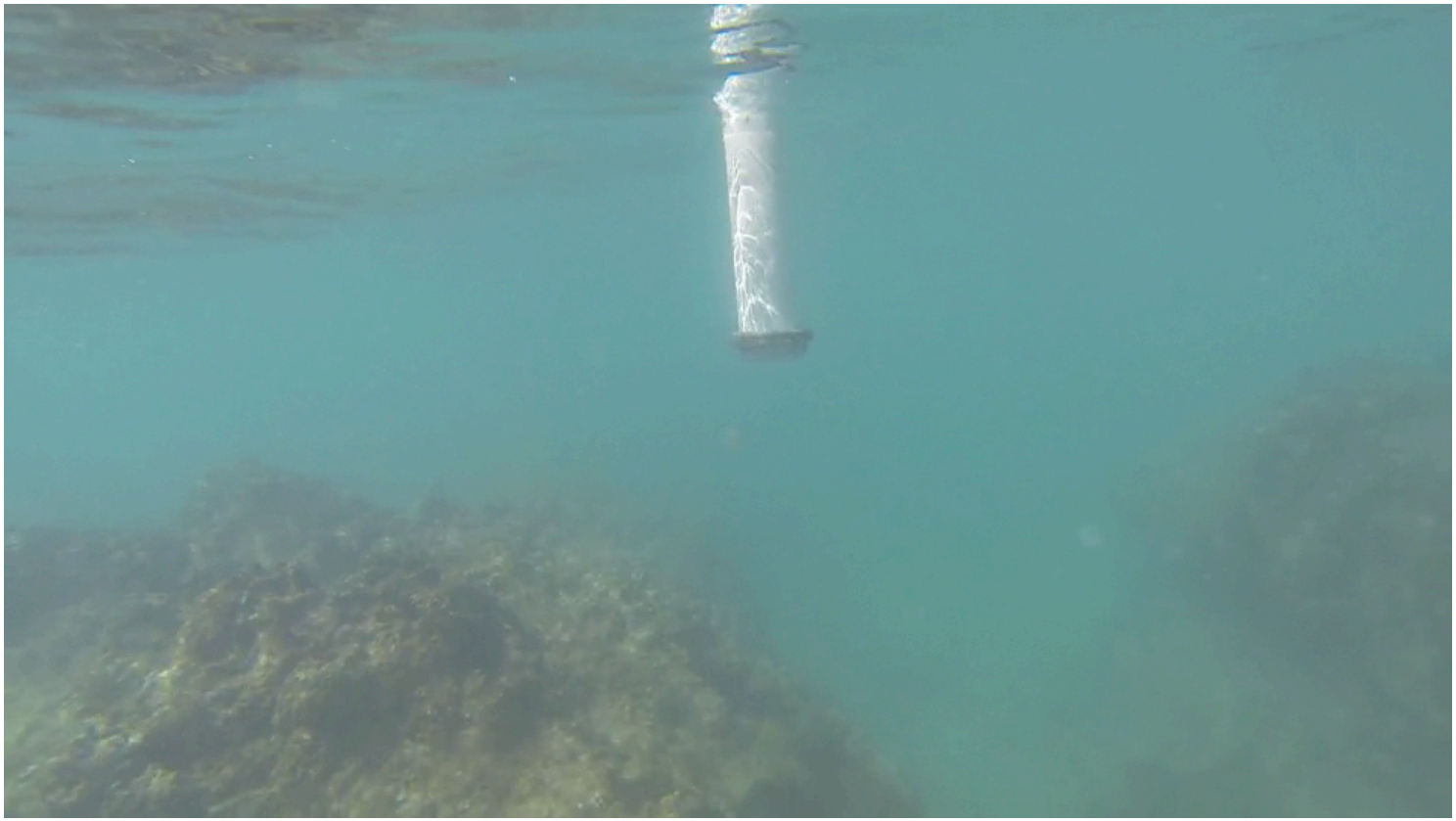
Capstone Project: Drift Nodes

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



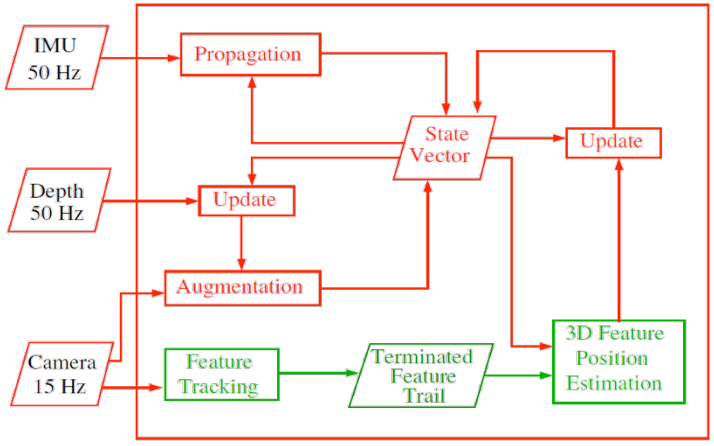
Marine Robotics: Drift Nodes

- Monitor, shallow coral reefs.
- Improve estimation accuracy

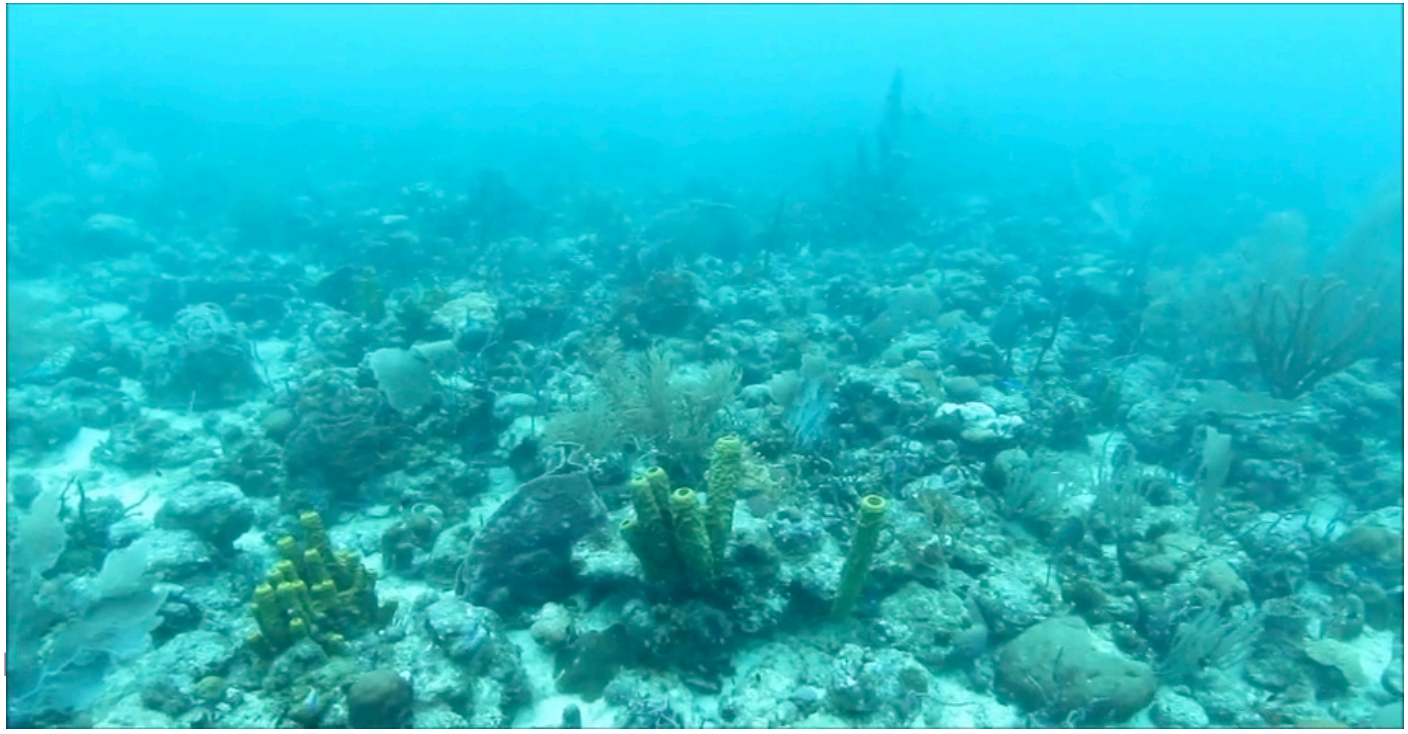


Marine Robotics

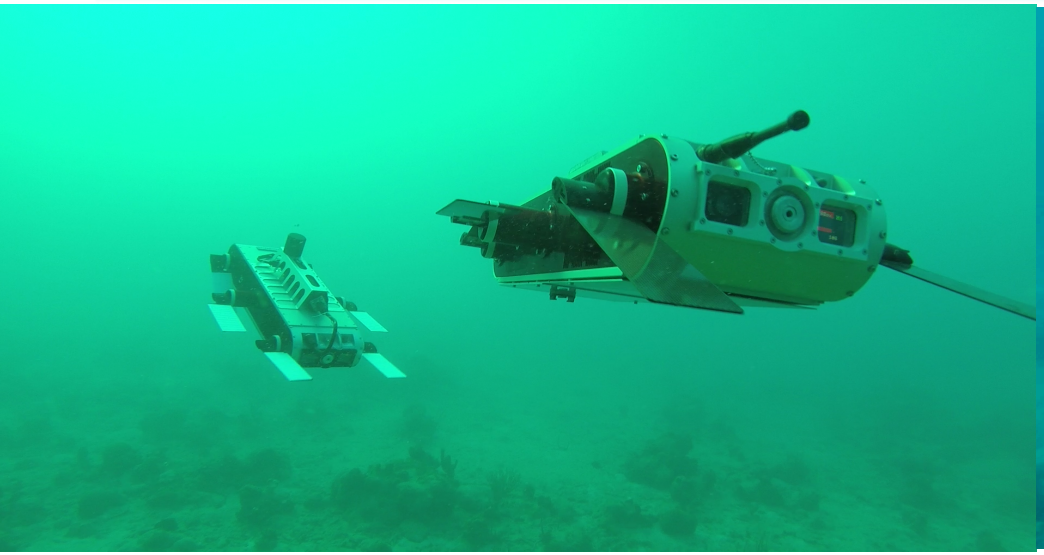
Underwater Situational Awareness

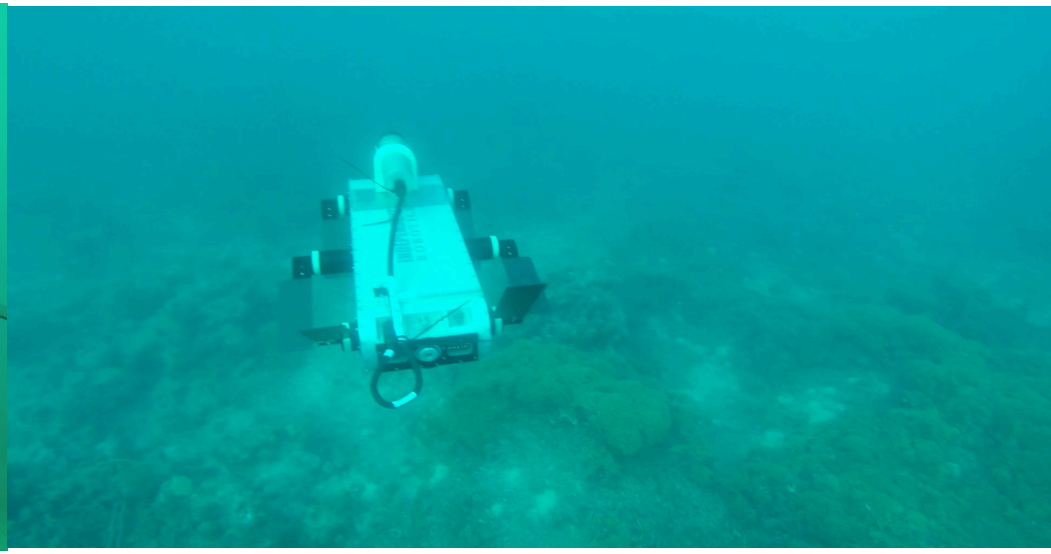


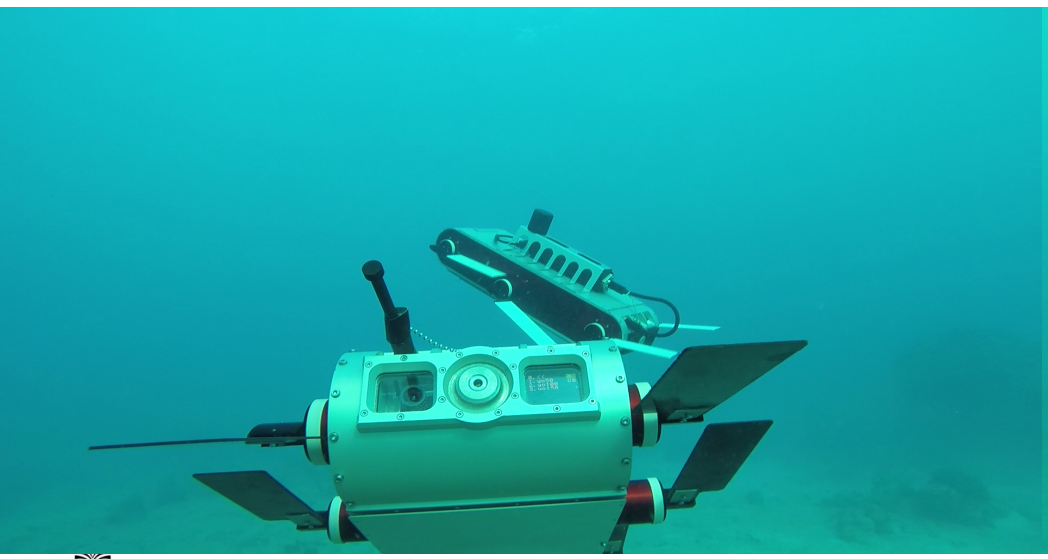
- Vision-INS State Estimation
- Path Planning
- Mapping

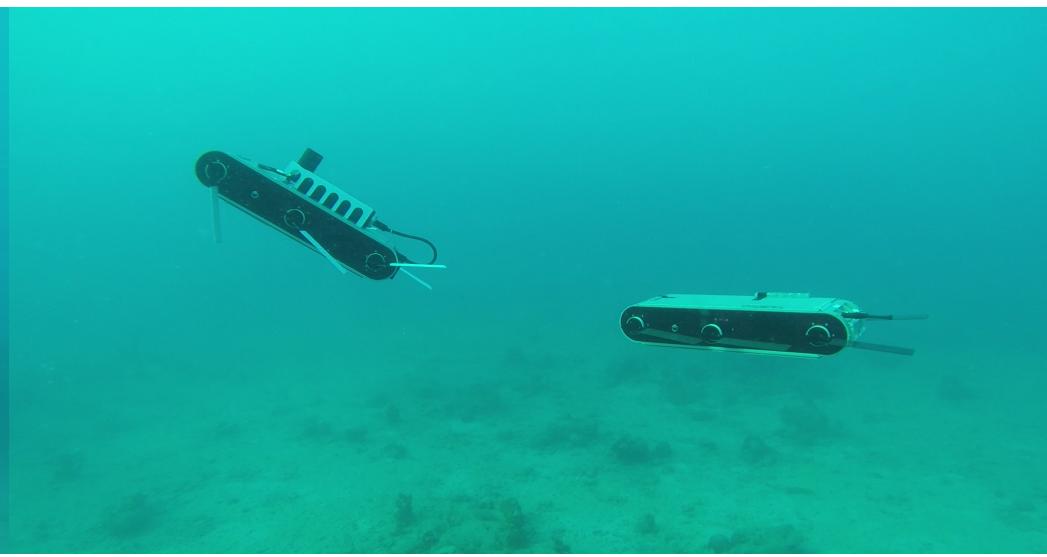


Marine Robotics



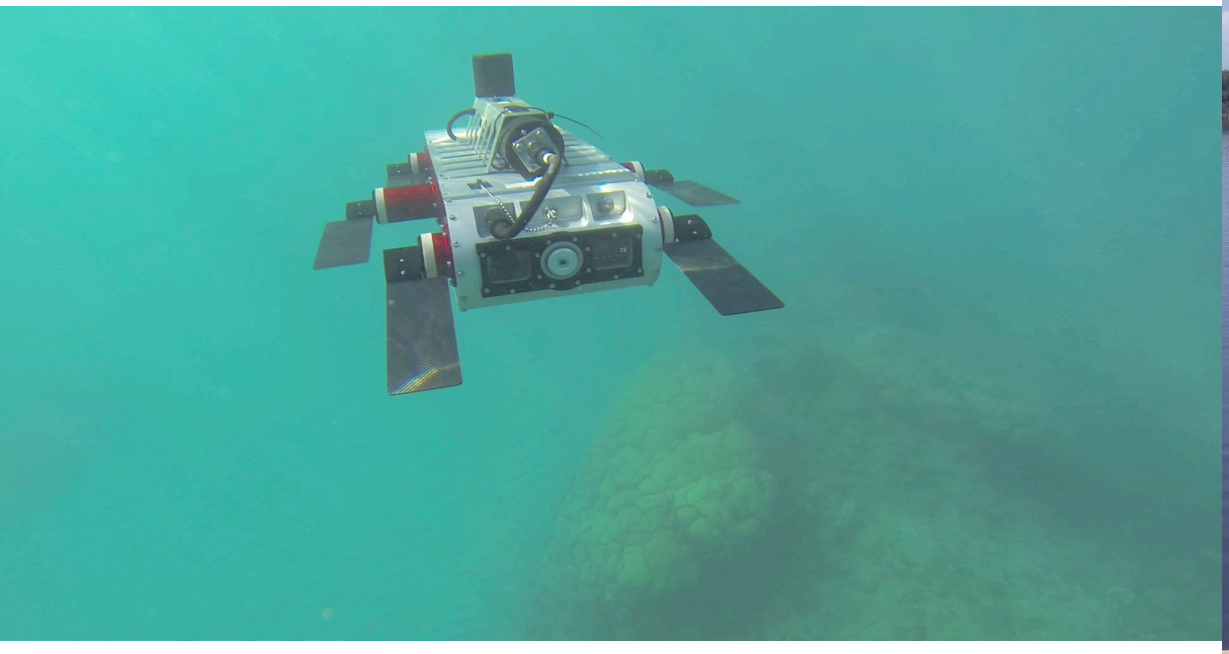






Vehicles

- Two Aqua with USBL

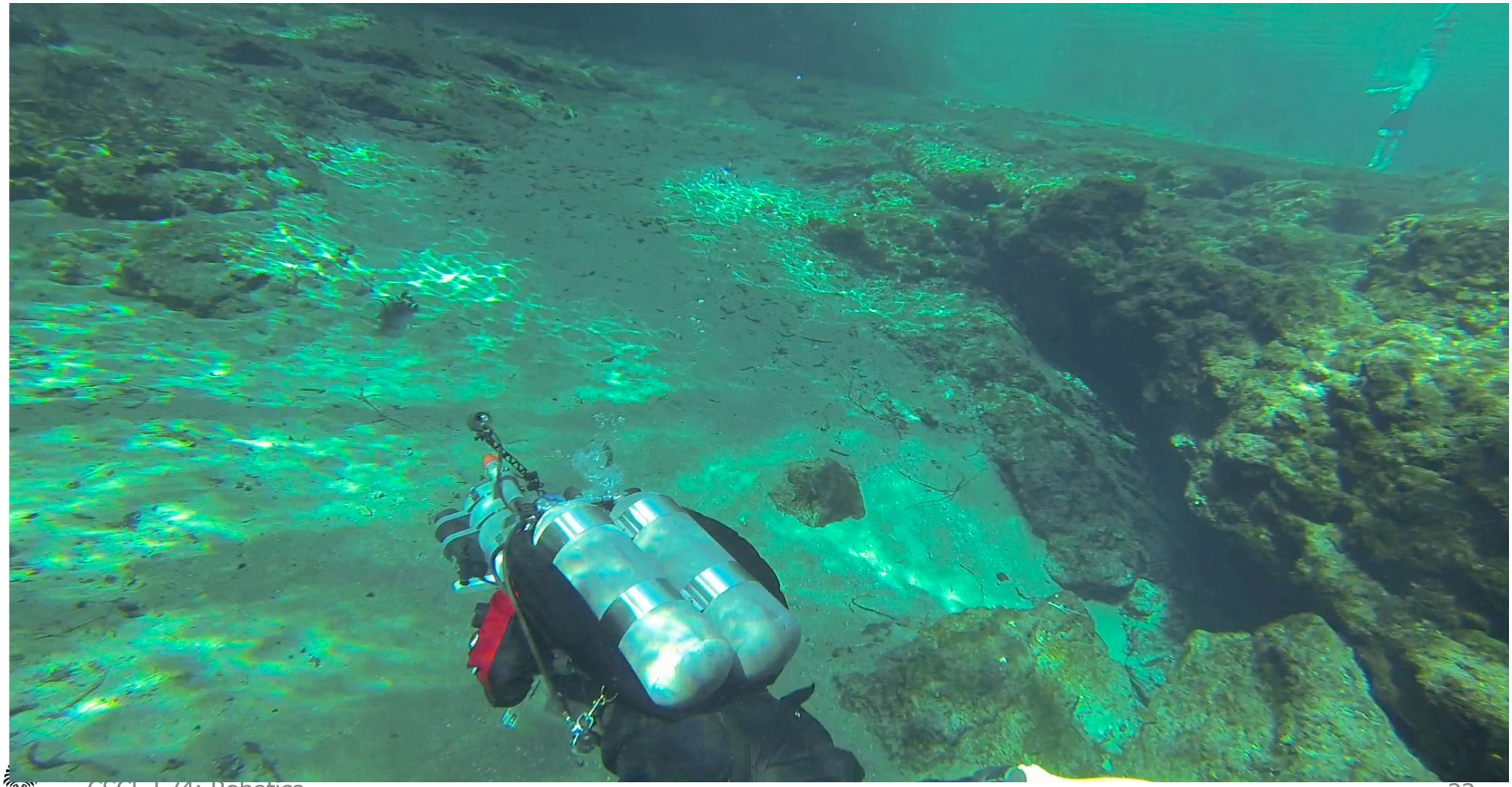


Vehicles

- Six ASVs

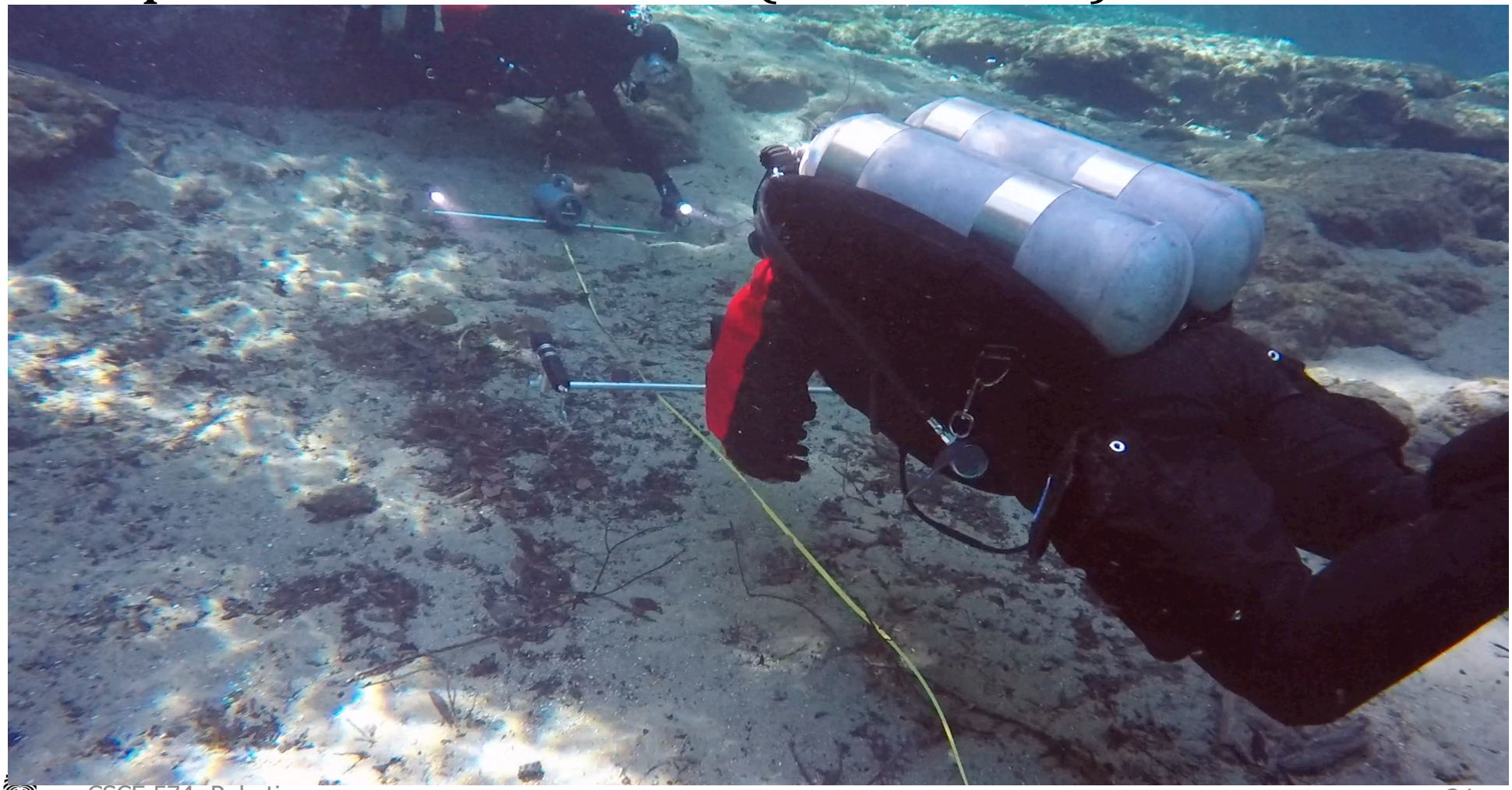
Sensors

- Stereo Rig – 2017 (made at SC)



Sensors

- Cooperative Localization (made at SC)



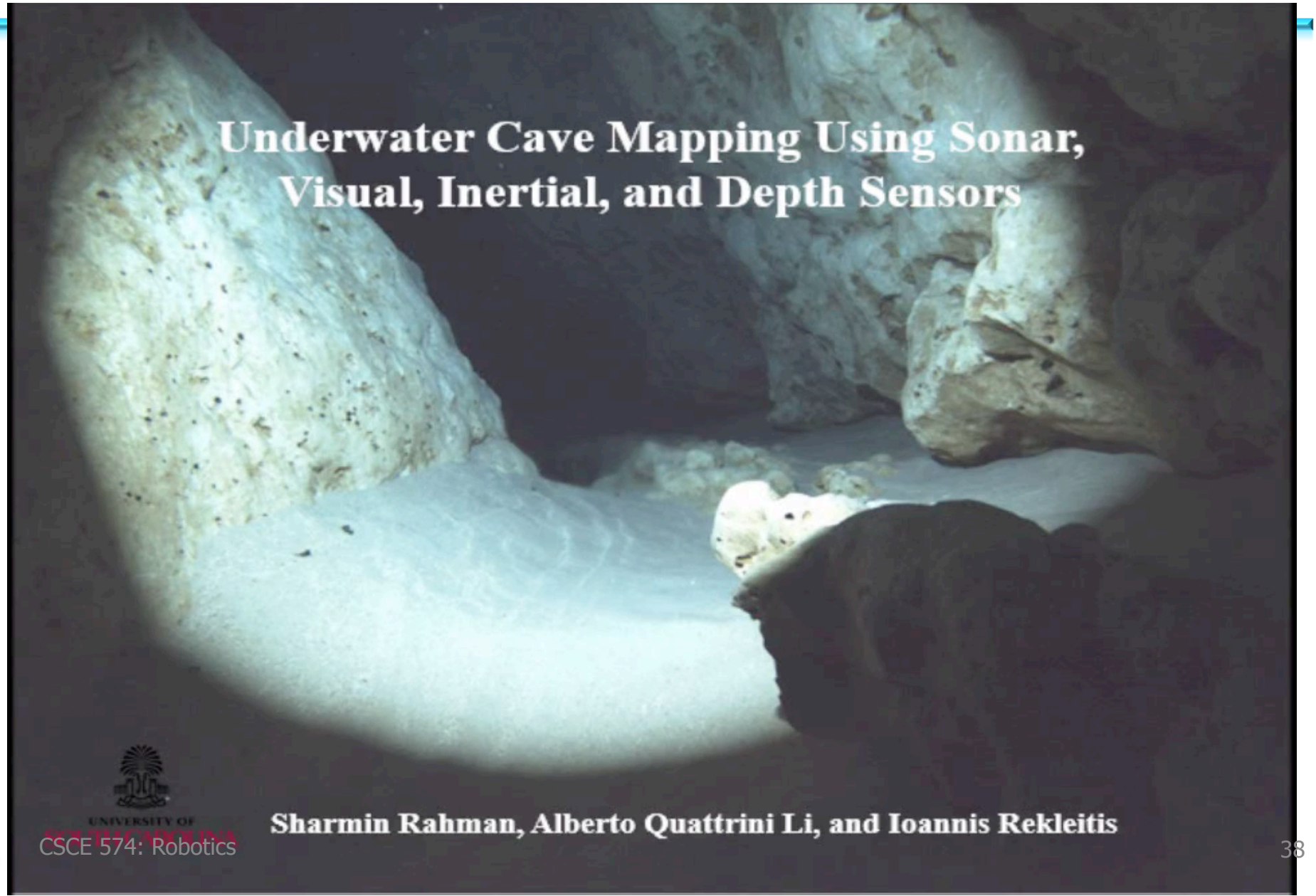
Shipwreck Mapping

Shipwreck Mapping

Robot's Eye View

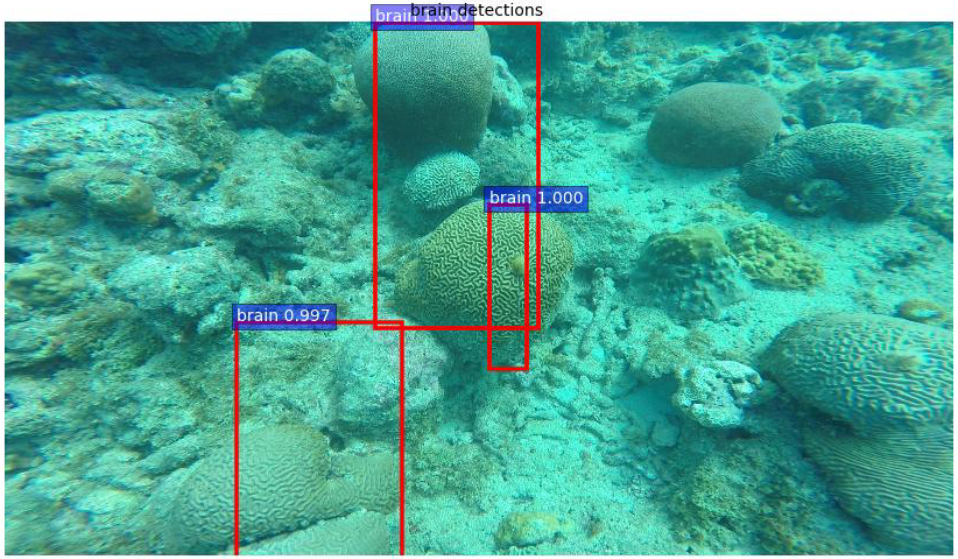
Underwater Cave Mapping

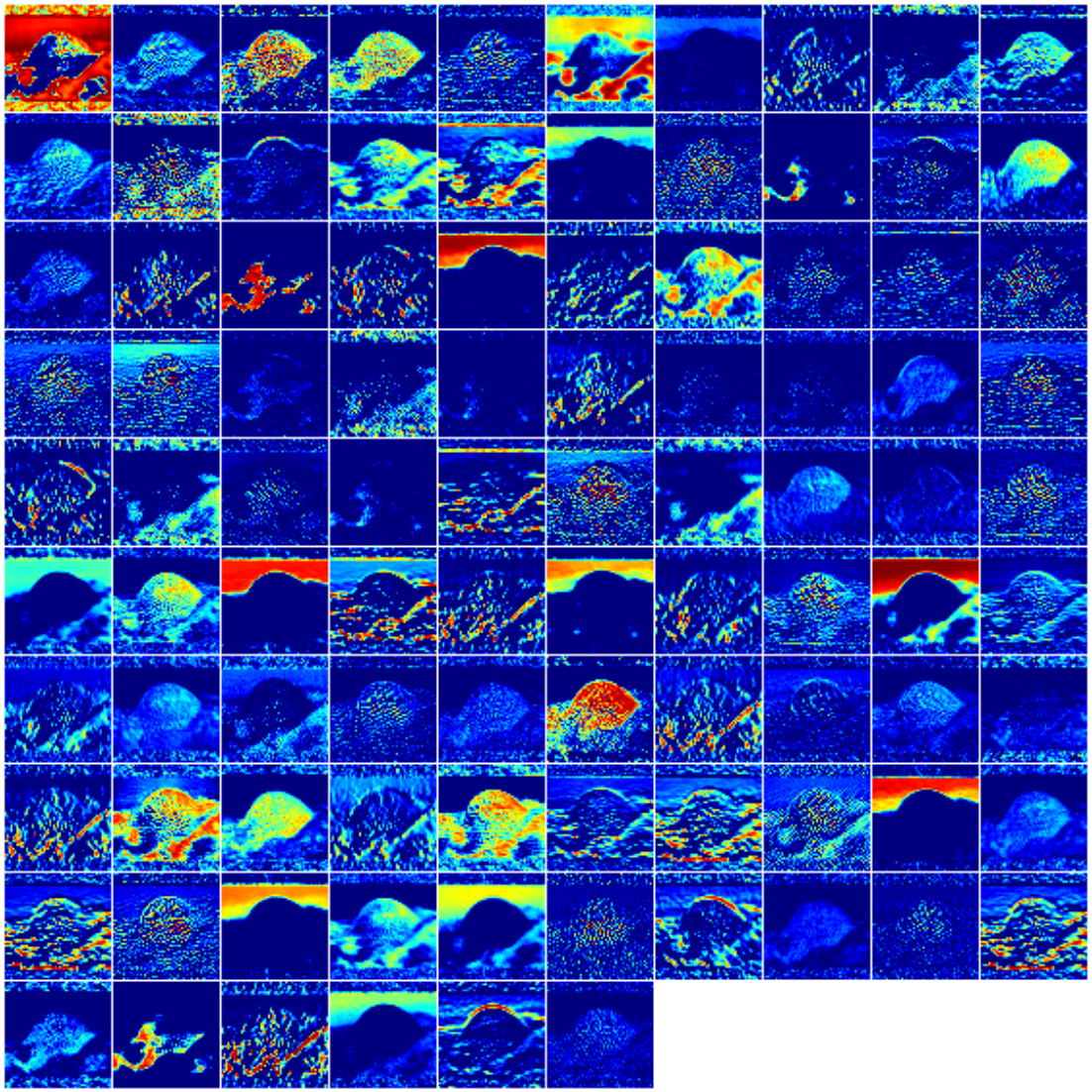
Underwater Cave Mapping



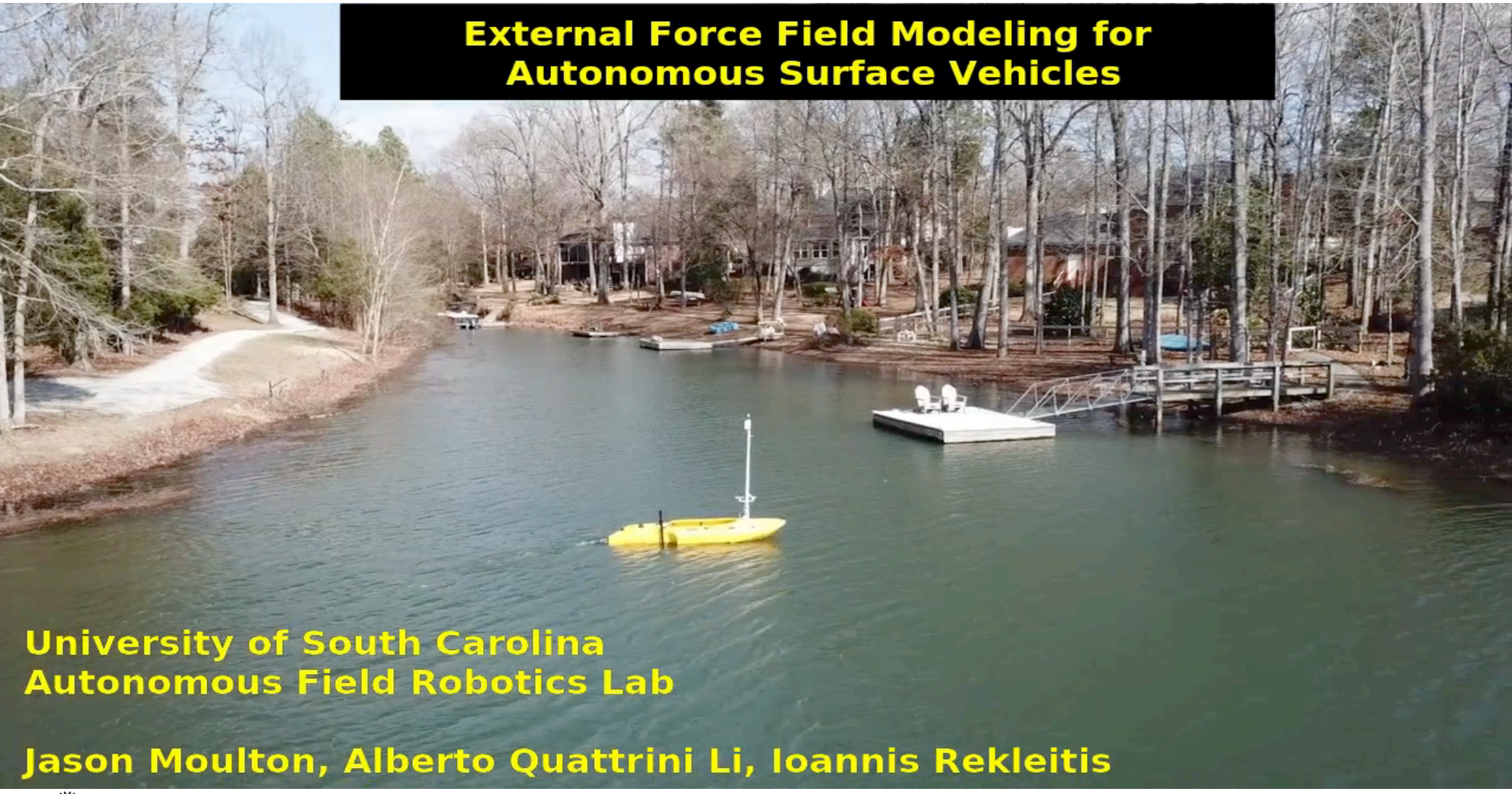
Shallow Coral Classification using Deep Learning

- Using a CNN





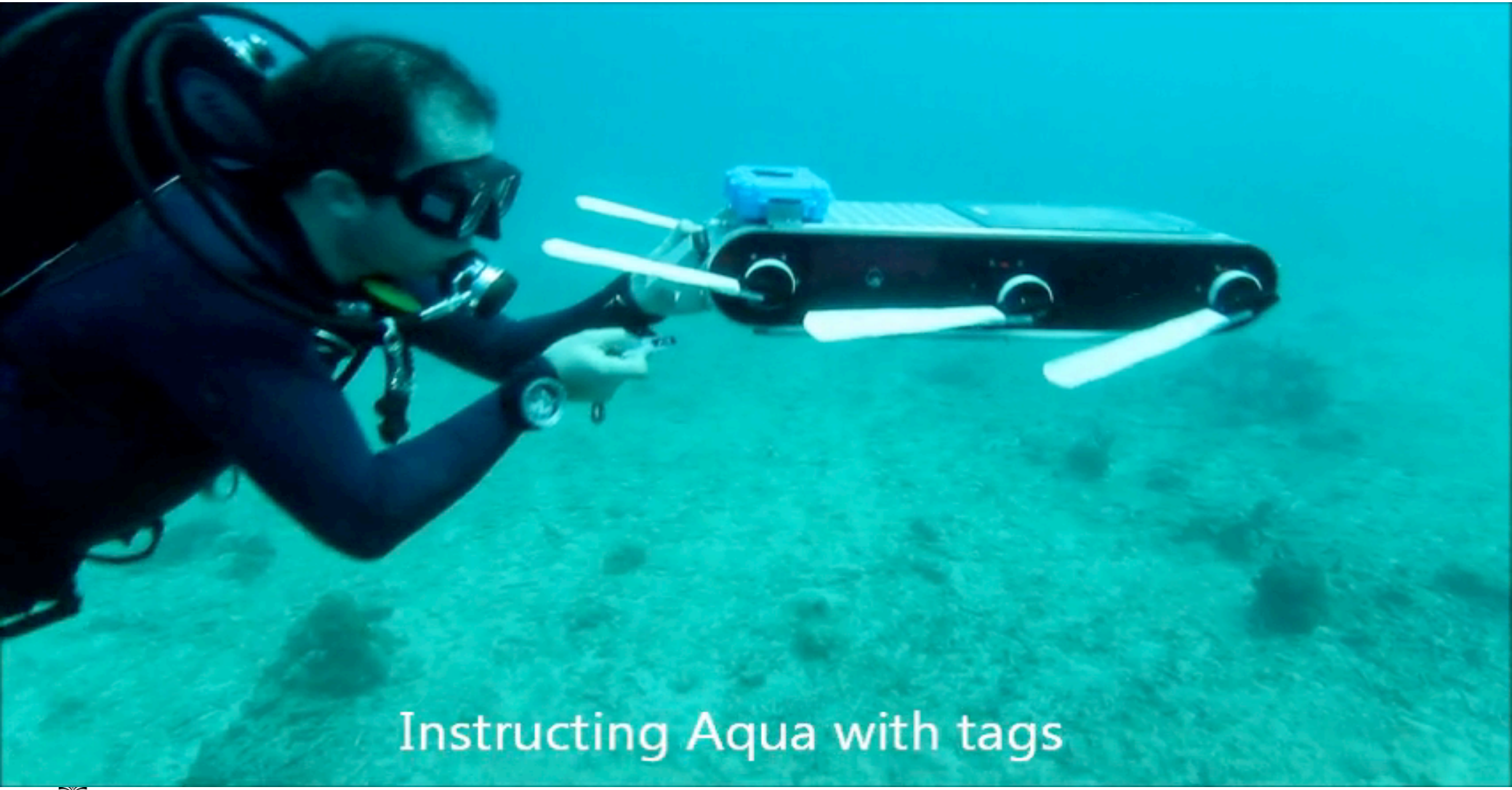
ASV Modeling of Adverse Conditions



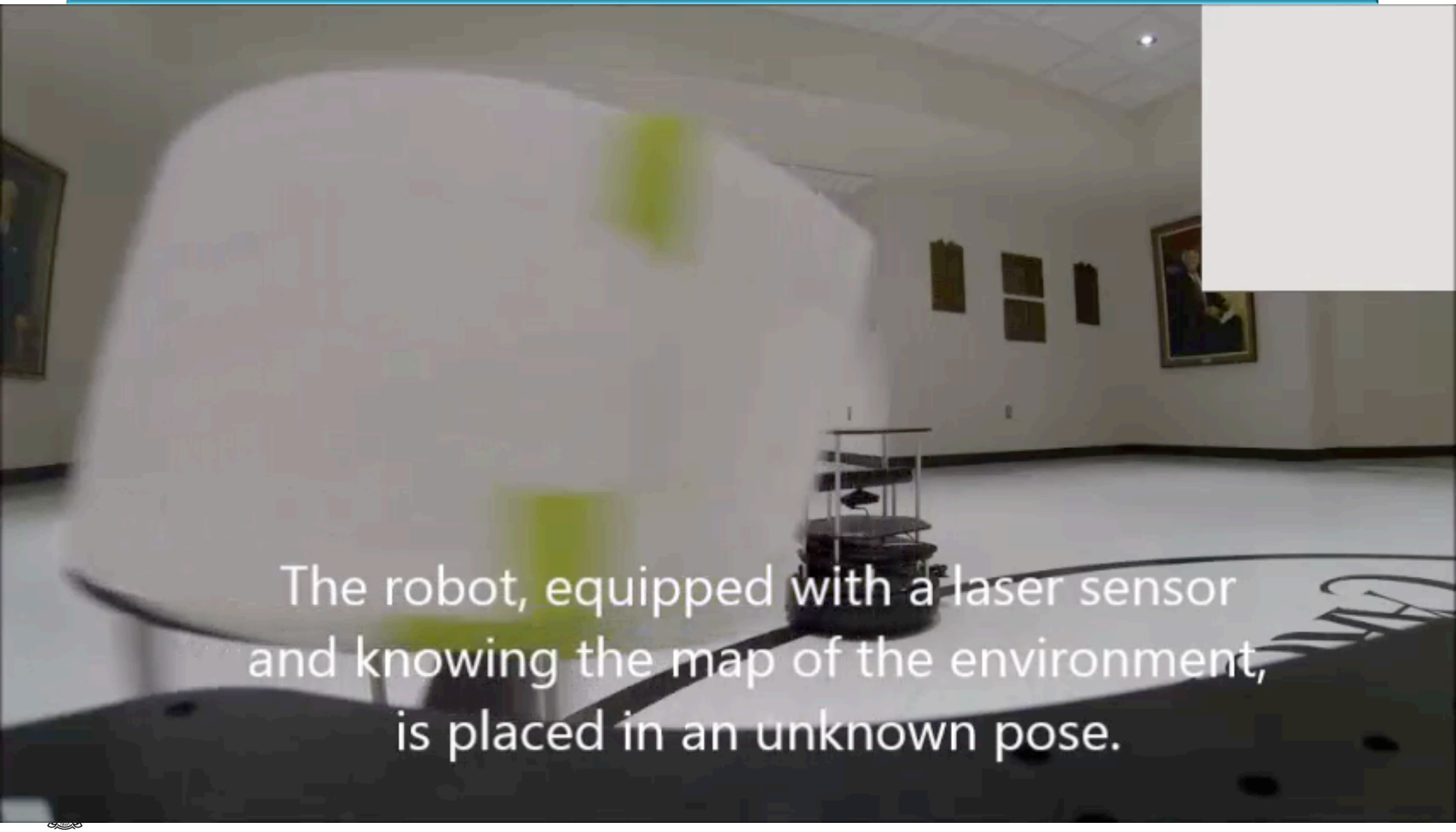
Single/Multi Robot Coverage
Dubins Vehicle kinematics

Marine Robotics:

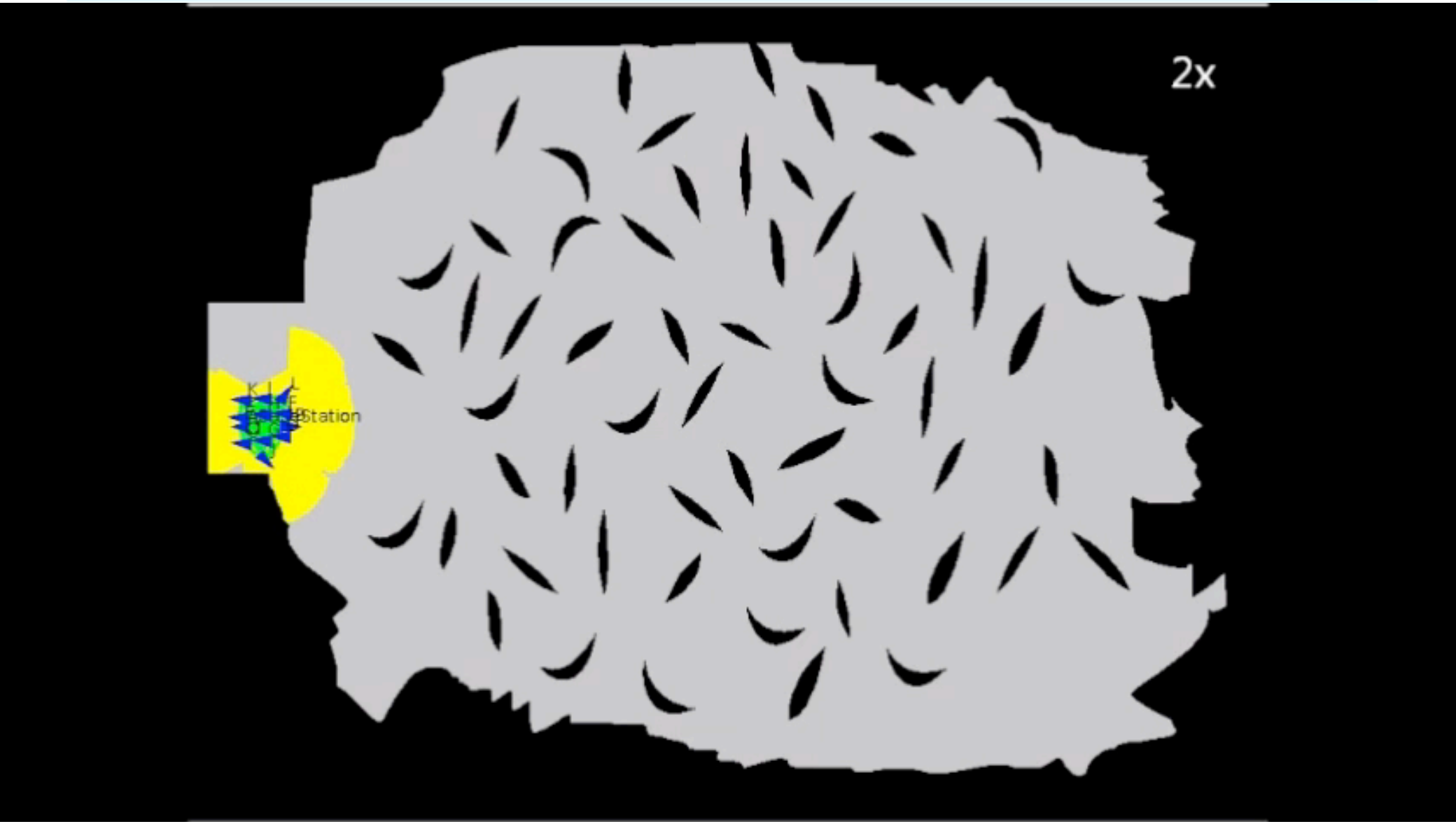
HRI with limited bandwidth



Indoor: Localization with dynamic obstacles



Indoor: Communication Constrained Exploration



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%

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/574/2018Fall/
- **Email**: yiannisr@cse.sc.edu

- **Office hours**: 2235– Mon/Wed 13:00-14:30
  and by appointment