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

<u>Present Everywhere</u>

- **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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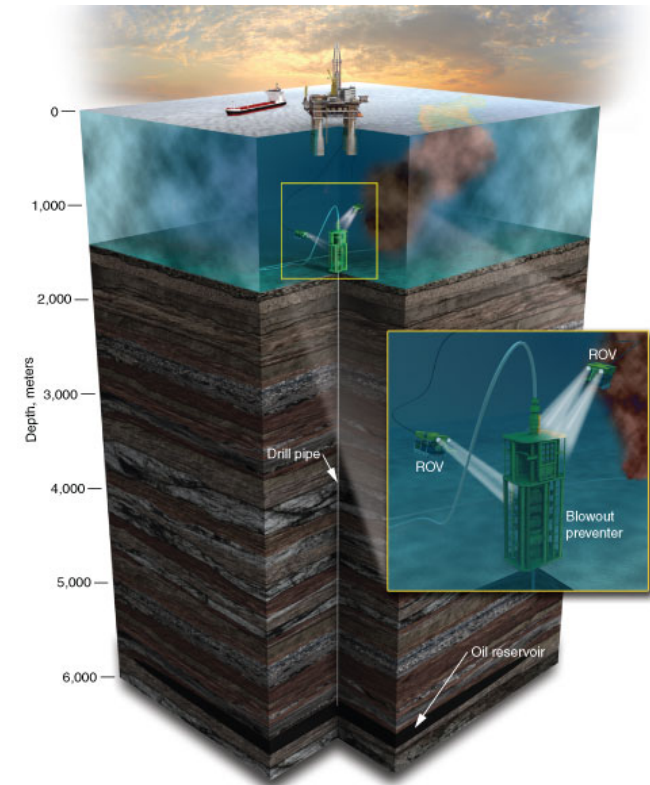- Education
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QUADH2O
MULTIROTOR

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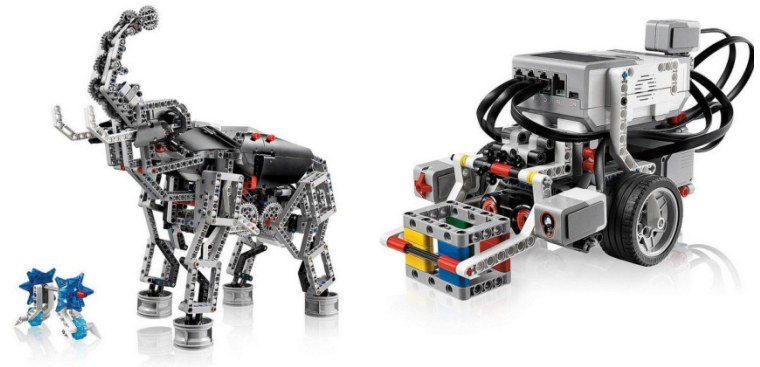- Education
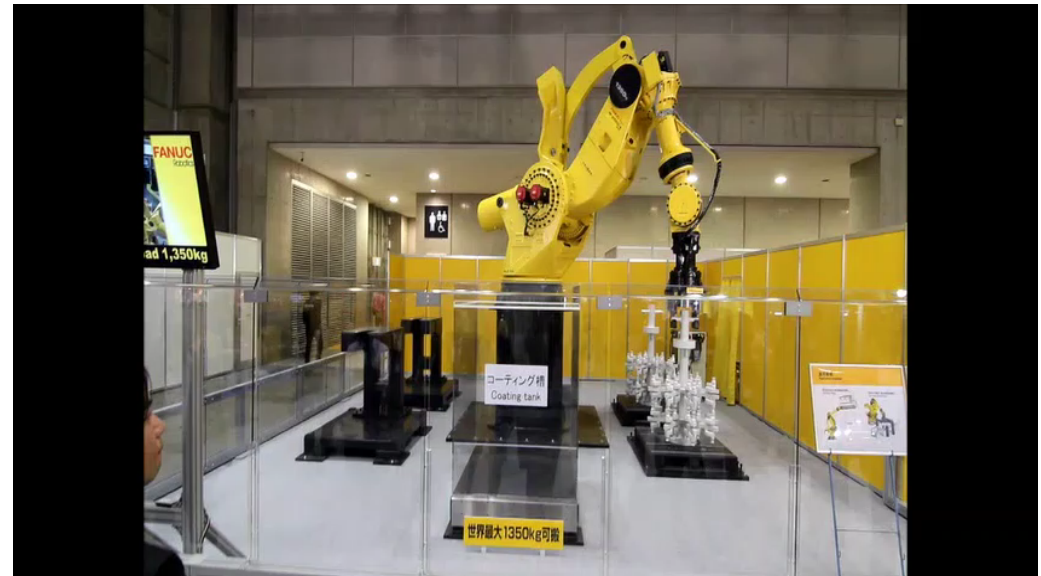- In Factories
- In Warehouses
- In Space

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- **In Warehouses**
- In Space

Amazon bought Kiva for $775M

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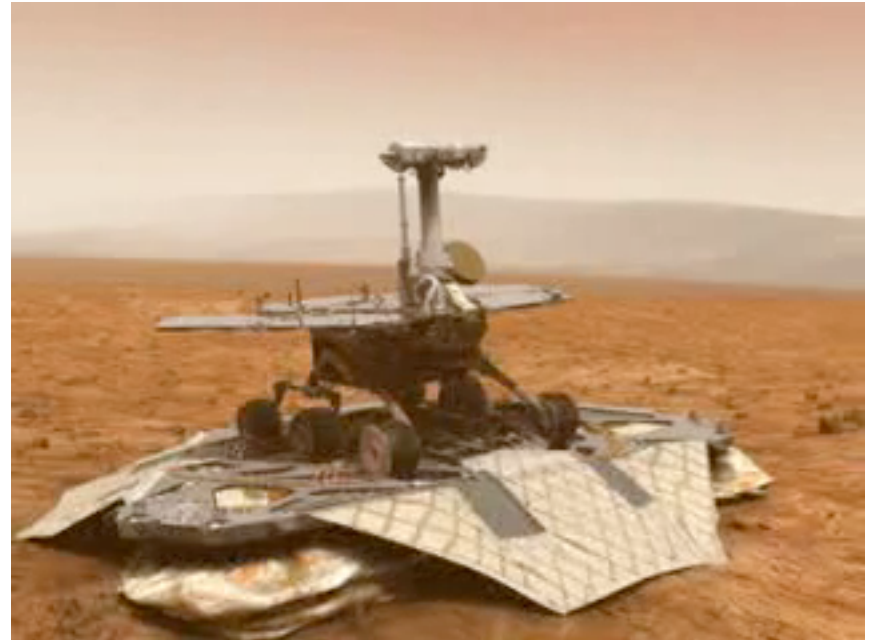
Robotic technology becomes affordable

TurtleBot 2

AR.DRONE

Kinect

IMU

Raspberry Pi

GPS
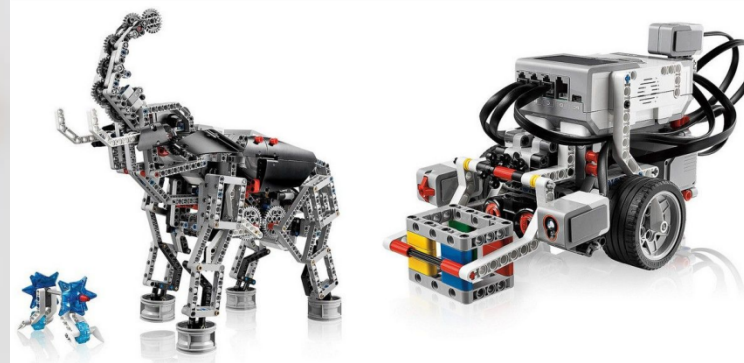
Lego Mindstorm

Robotics at USC

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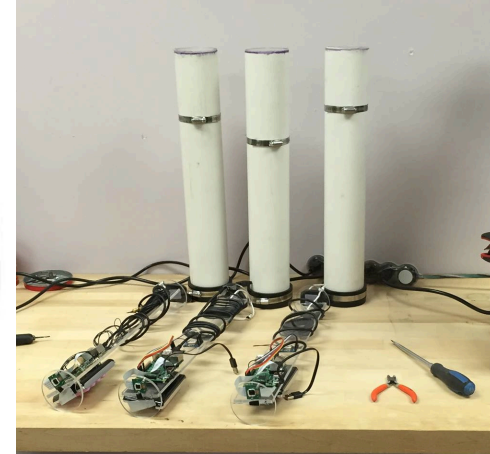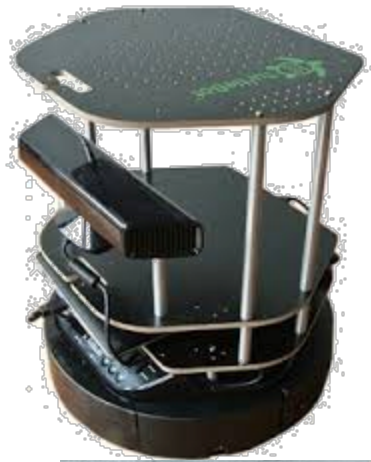
Autonomous Field Robotics Lab

Autonomous Field Robotics Lab

Develop algorithms for robotic applications

Philosophy

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
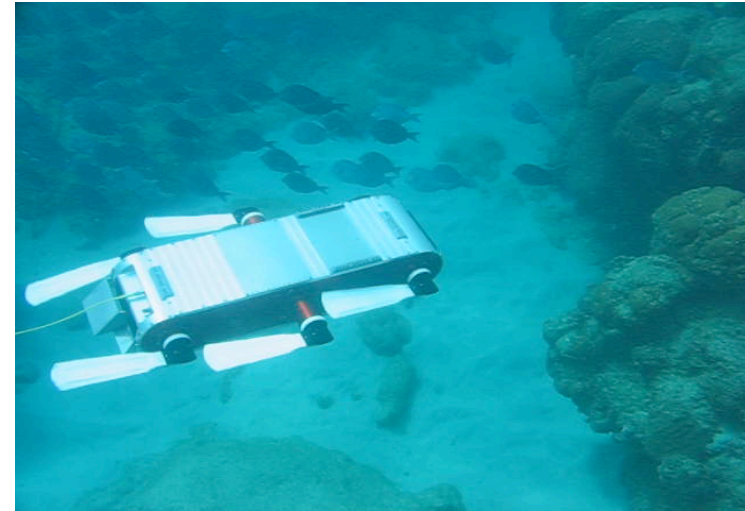
Several **Surface Vehicles**

2 **Aqua** u/w vehicles

Aerial Vehicles:
2 fixed wings
2 quadrotor

Recent Funding:

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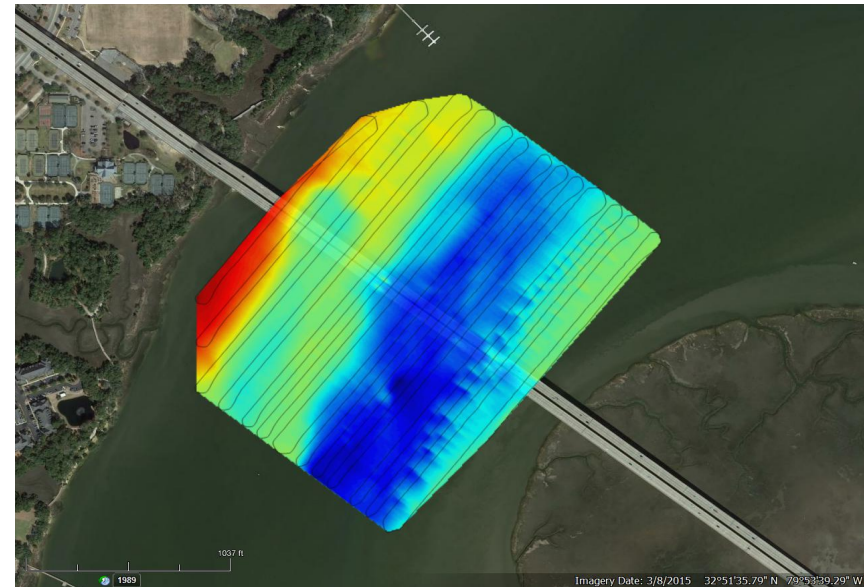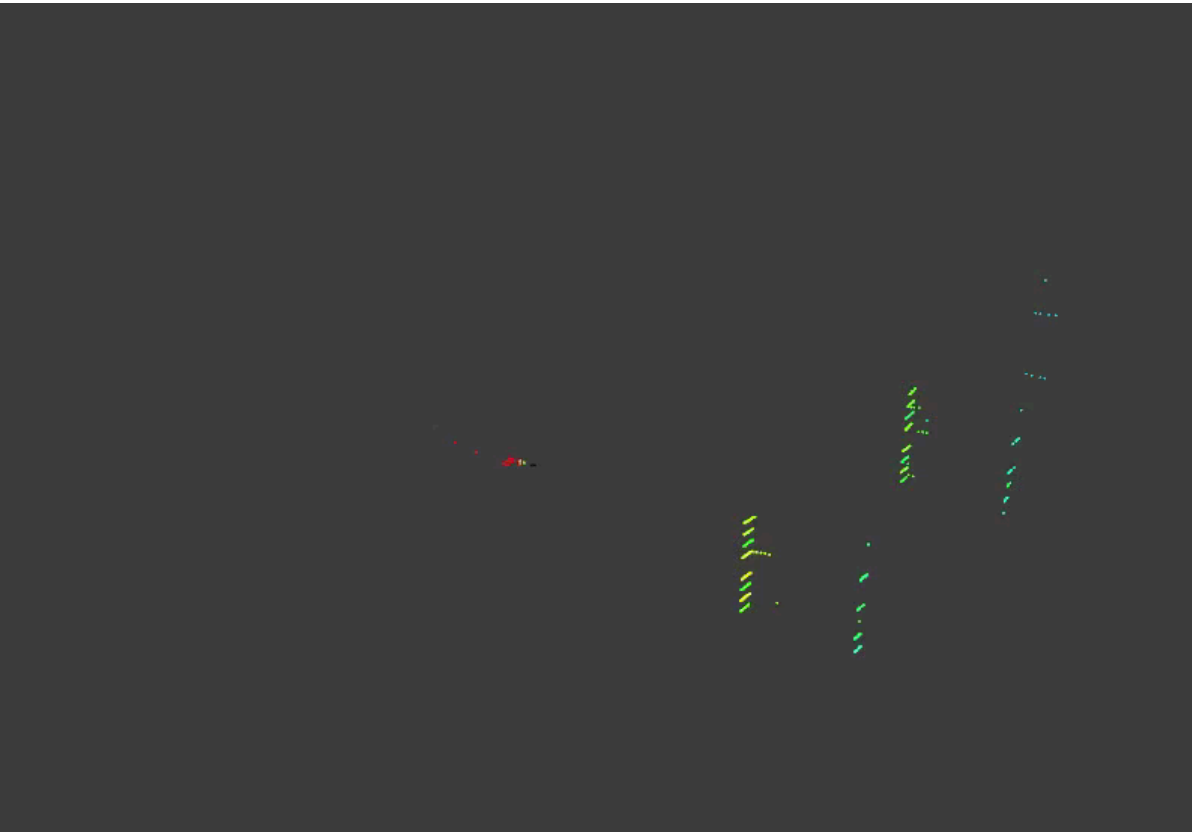
Recent Funding:

- **Google Faculty Research Awards**: Underwater Street View: Wreck Mapping off the Carolinas

- **PI**: I. Rekleitis

- 2016-2017
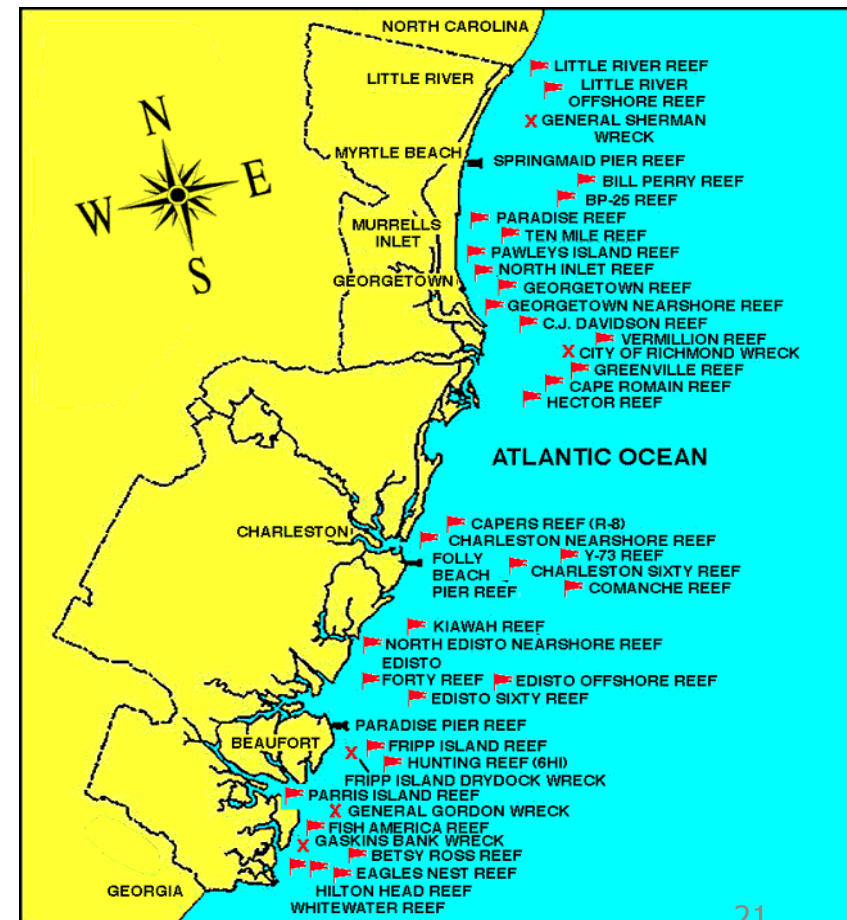
Recent Funding:

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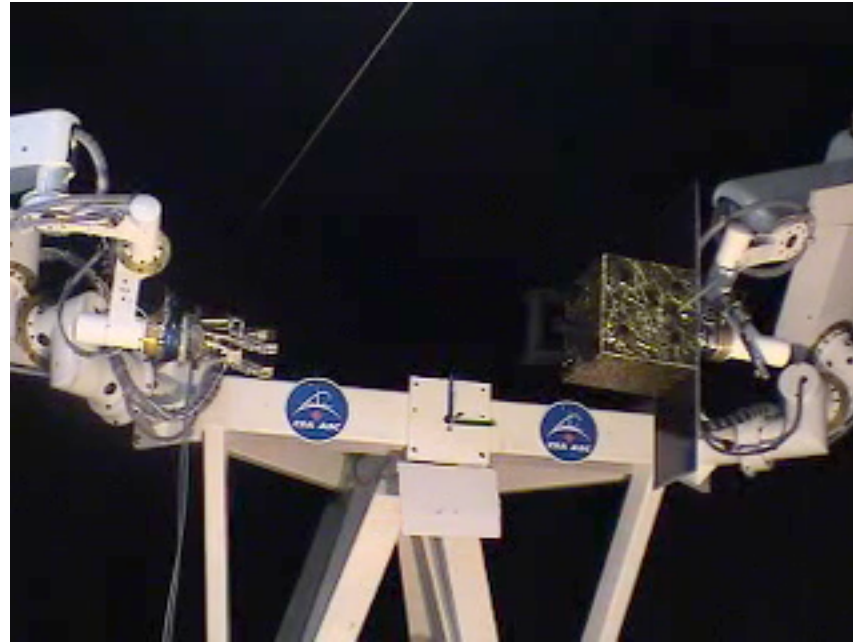- **PI**: I. Rekleitis
- **Funding**: 2016-2019

SONAR-Vision Fusion

Stereo Based 3D Reconstruction
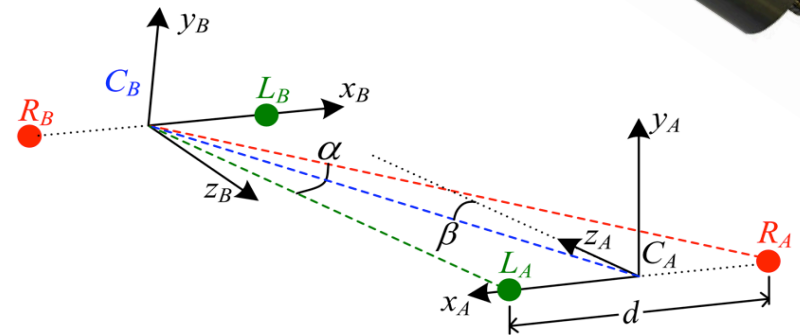
Cooperative Localization

Past Projects
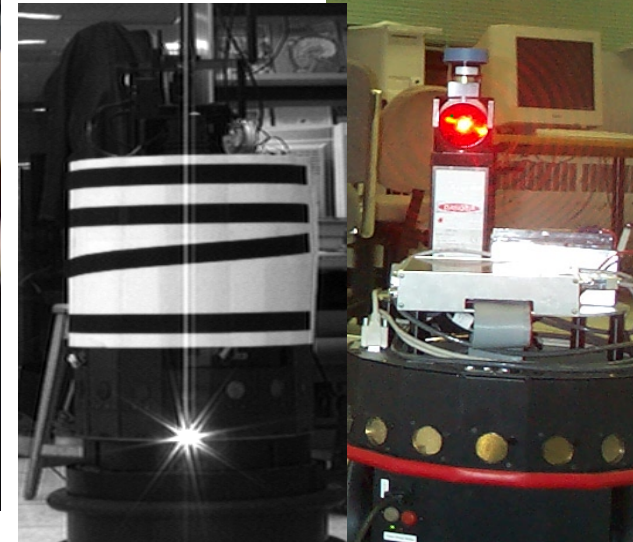
Past Projects
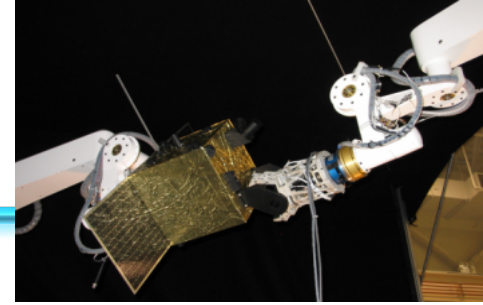
Complete Optimal Terrain Coverage
using an Unmanned Aerial Vehicle

Anqi Xu
Chatavut Viriyasuthee
Ioannis Rekleitis

McGill

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

Look Ma - No Motion Capture!

Coral Reef Monitoring by Heterogeneous Robots

Marine Robotics

Capstone Project: Drift Nodes

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

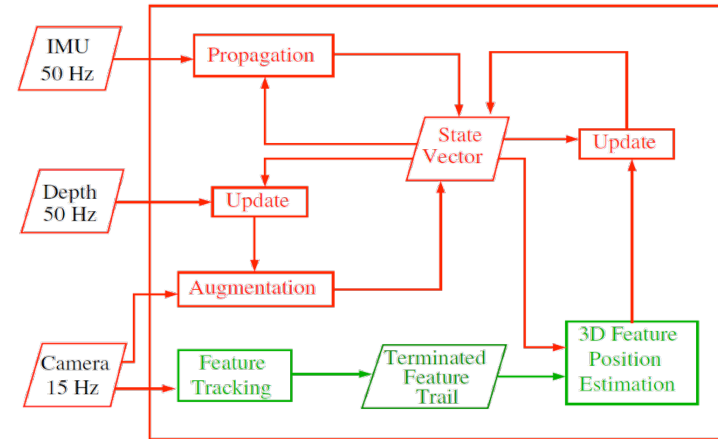- Improve estimation accuracy
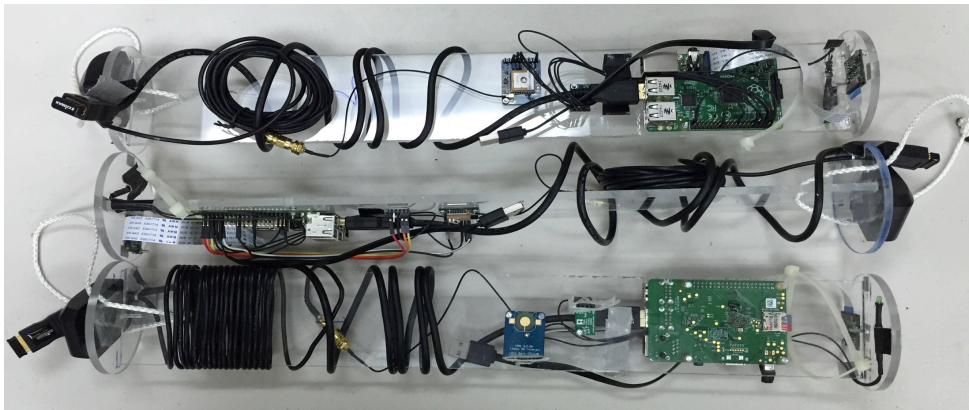
Marine Robotics: Drift Nodes

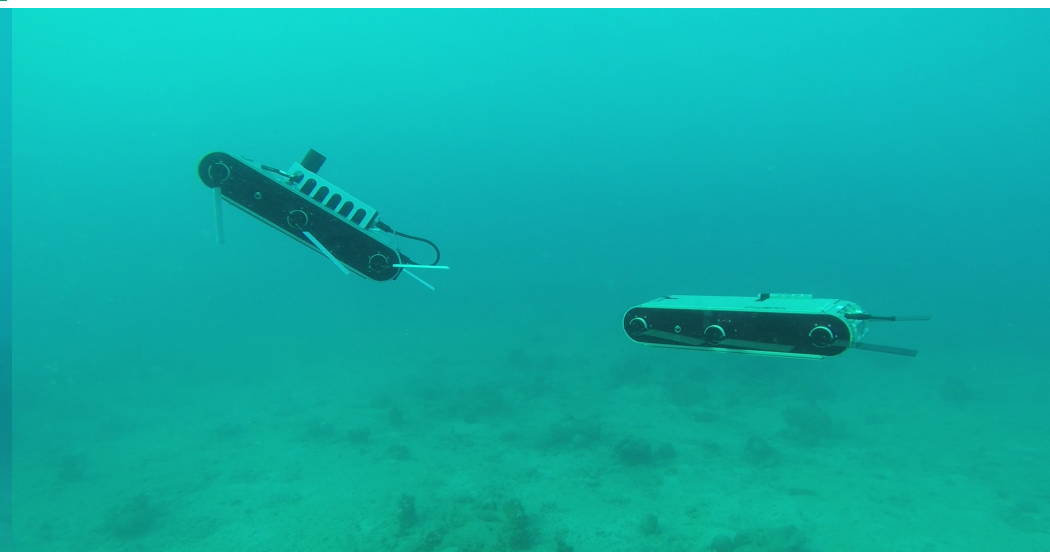- Monitor, shallow coral reefs.
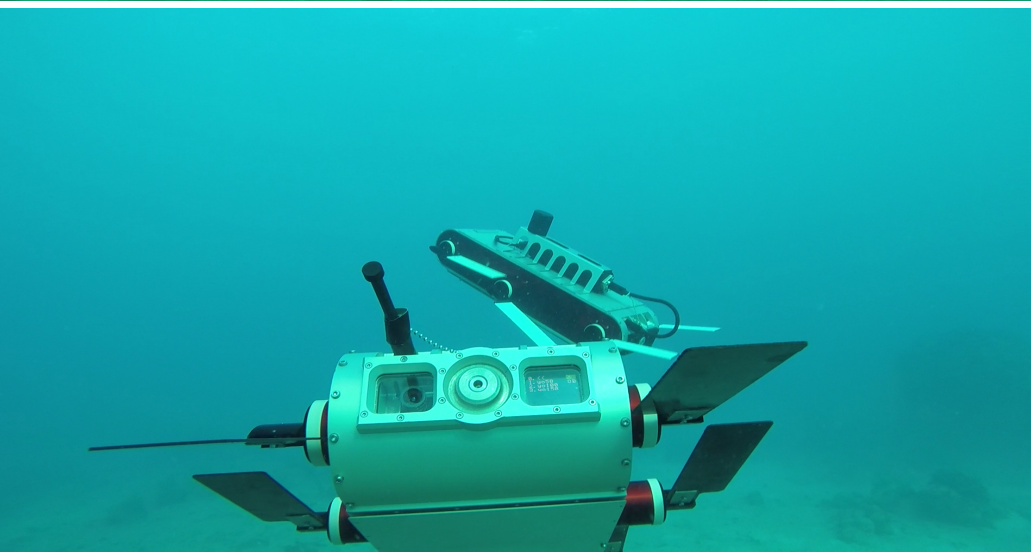
- Improve estimation accuracy
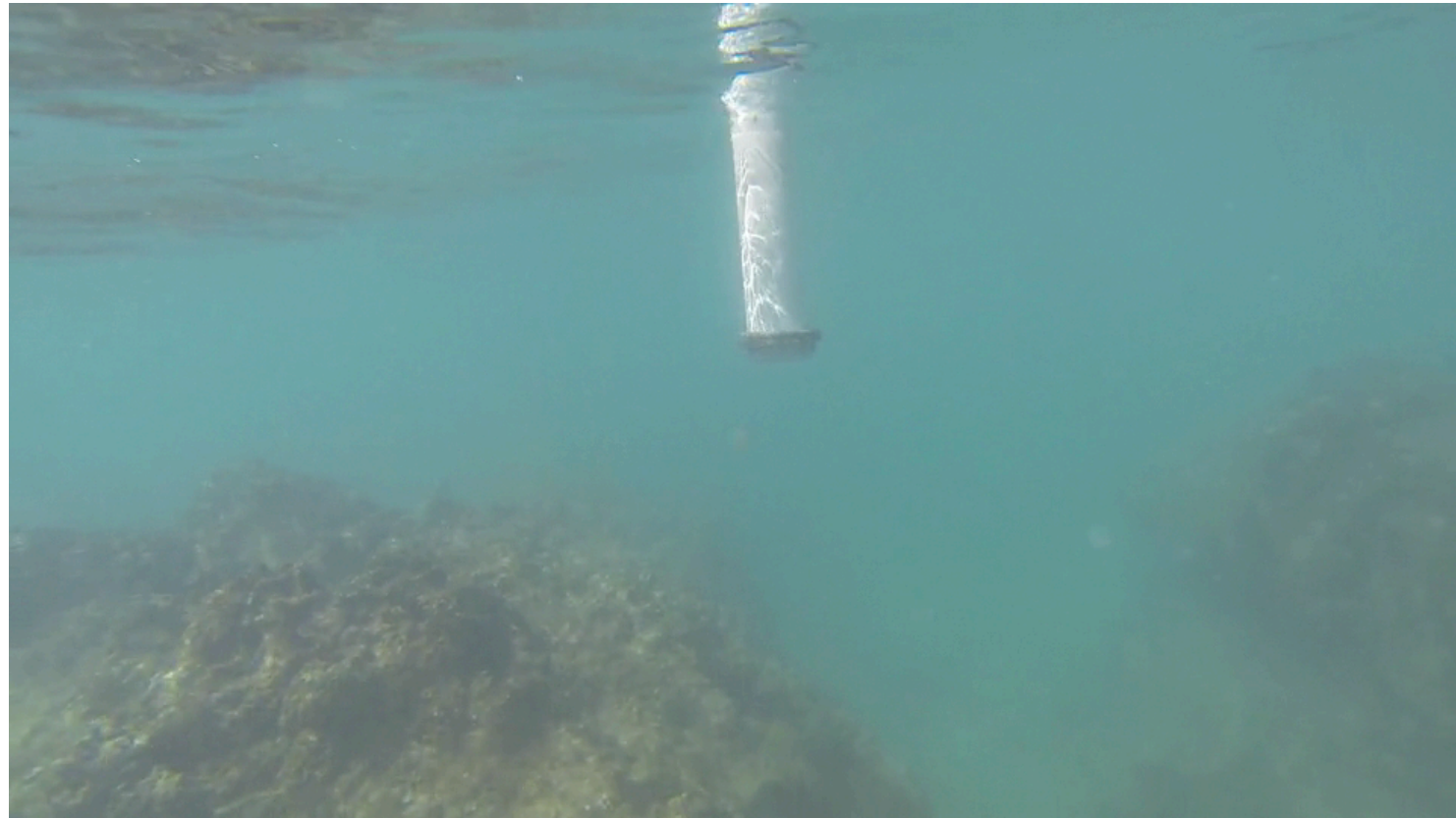
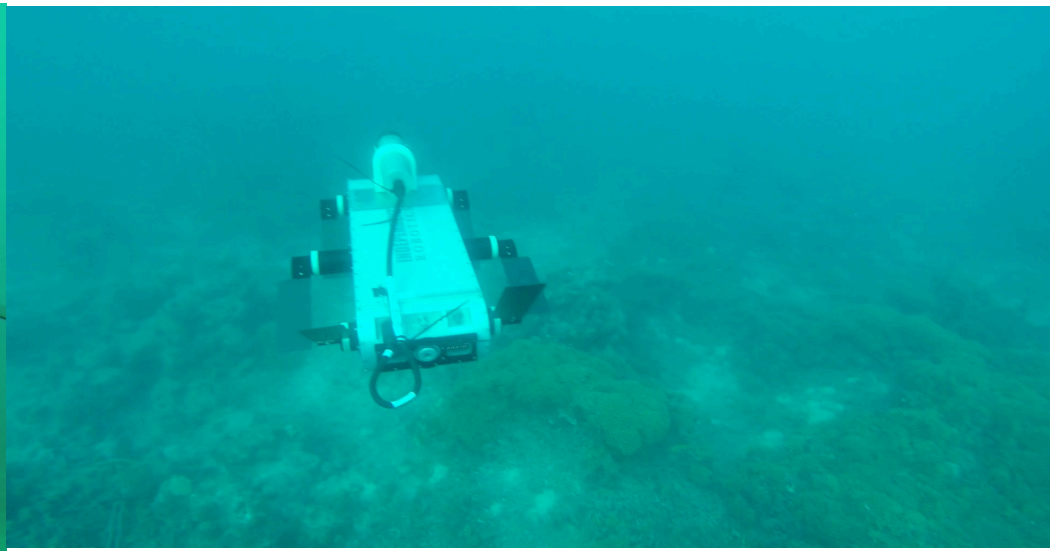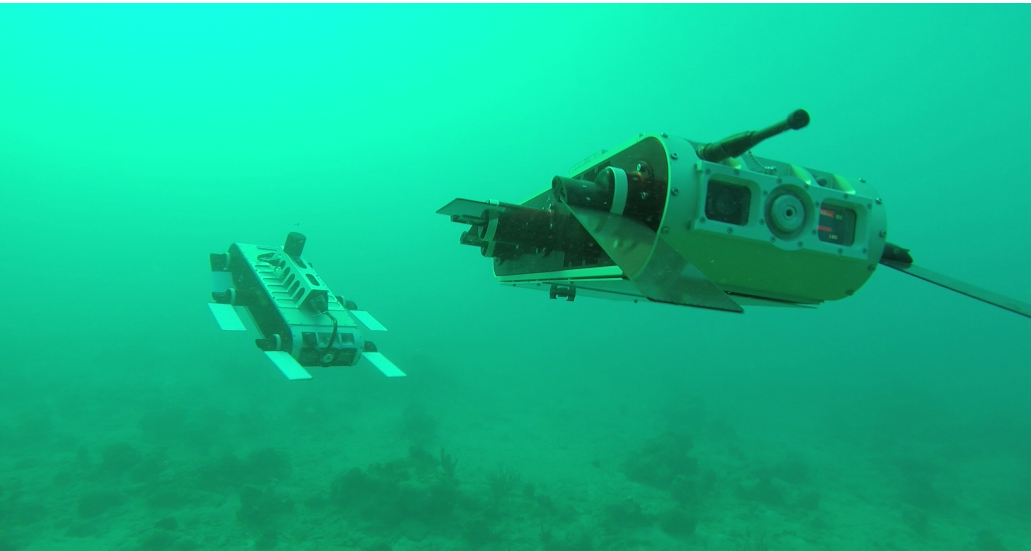# Marine Robotics

Underwater Situational Awareness

- Vision-INS State Estimation
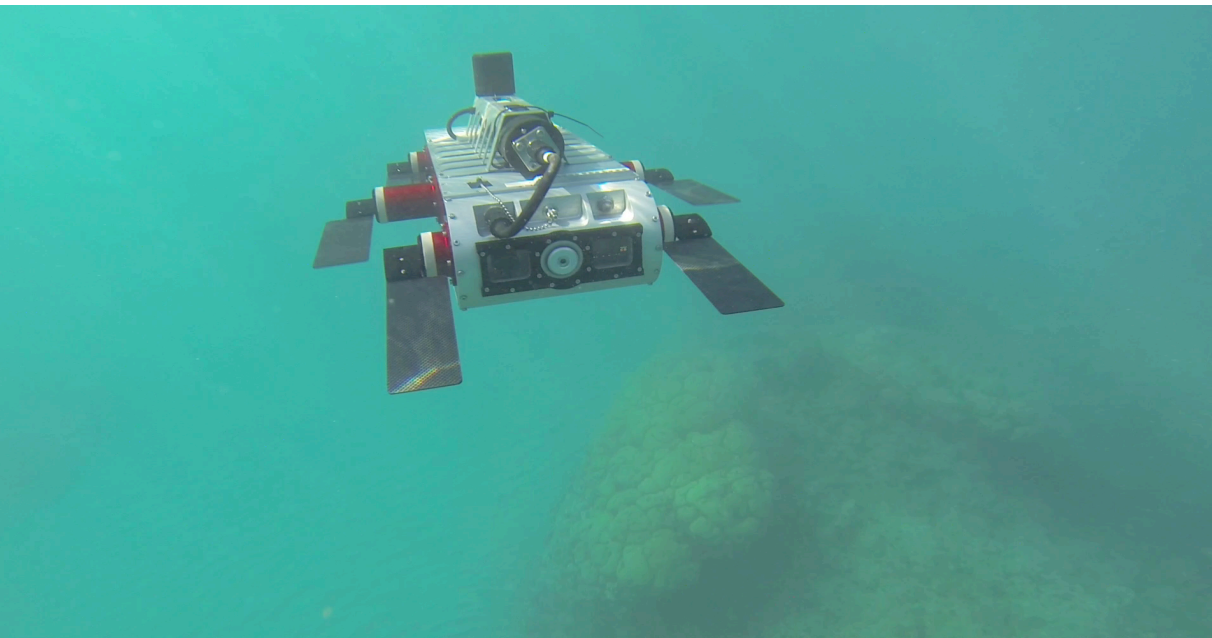- Path Planning
- Mapping
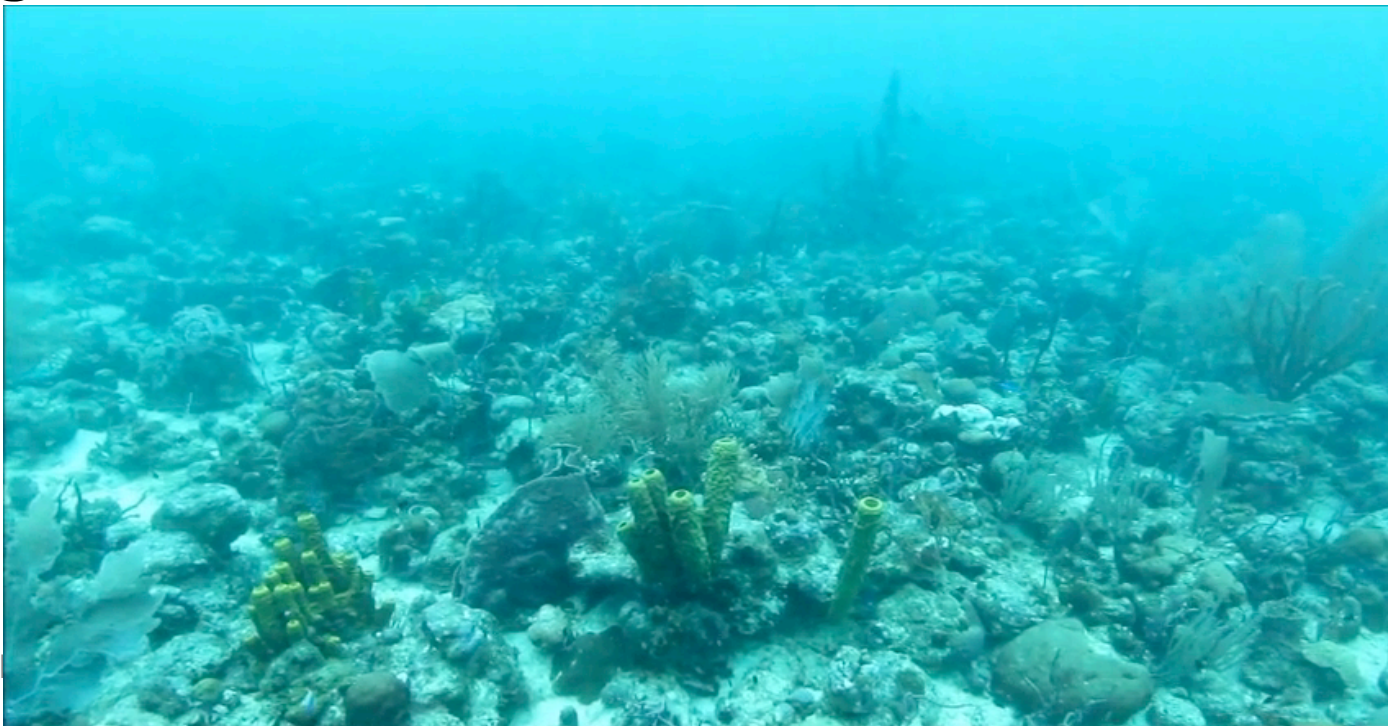
Marine Robotics
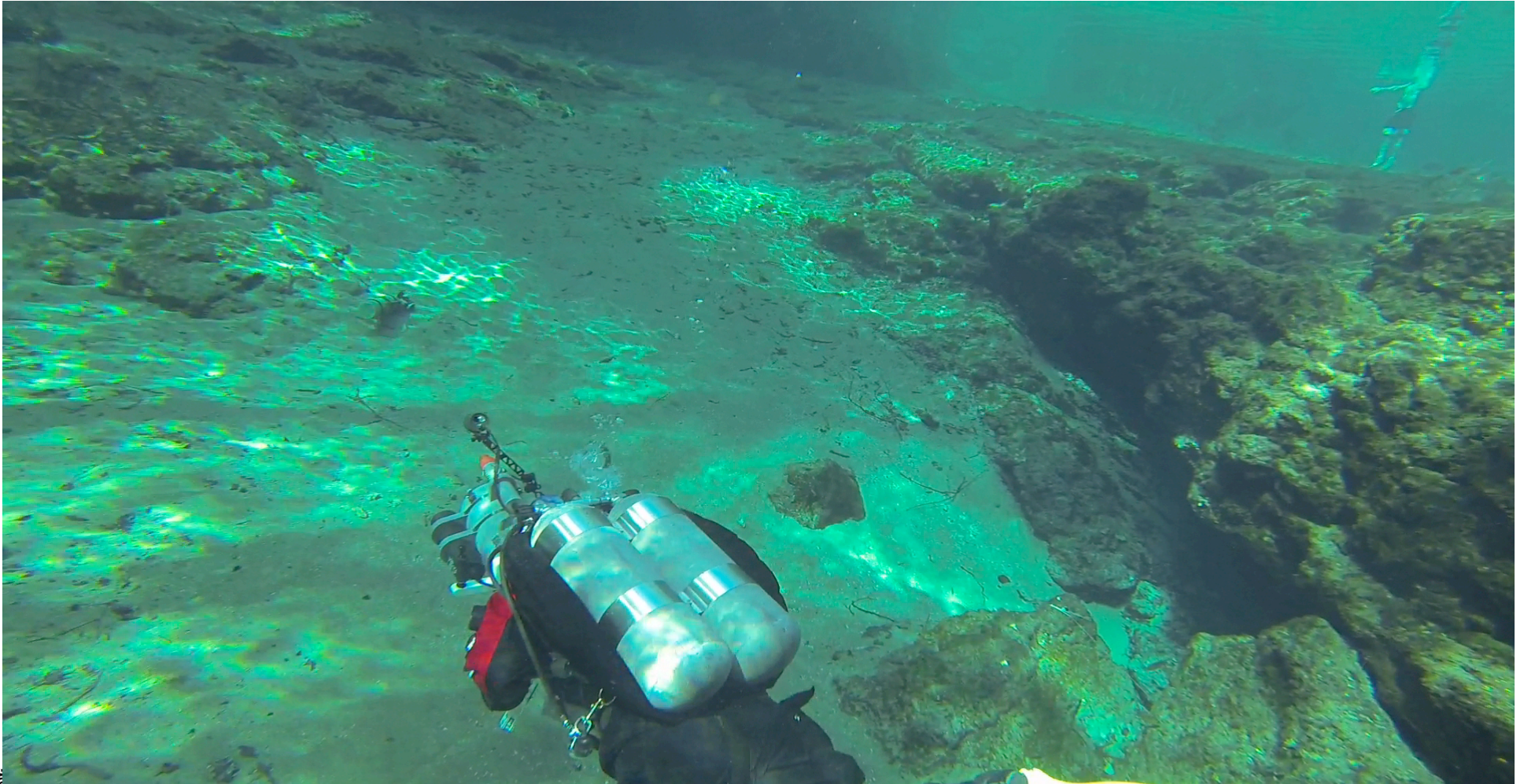
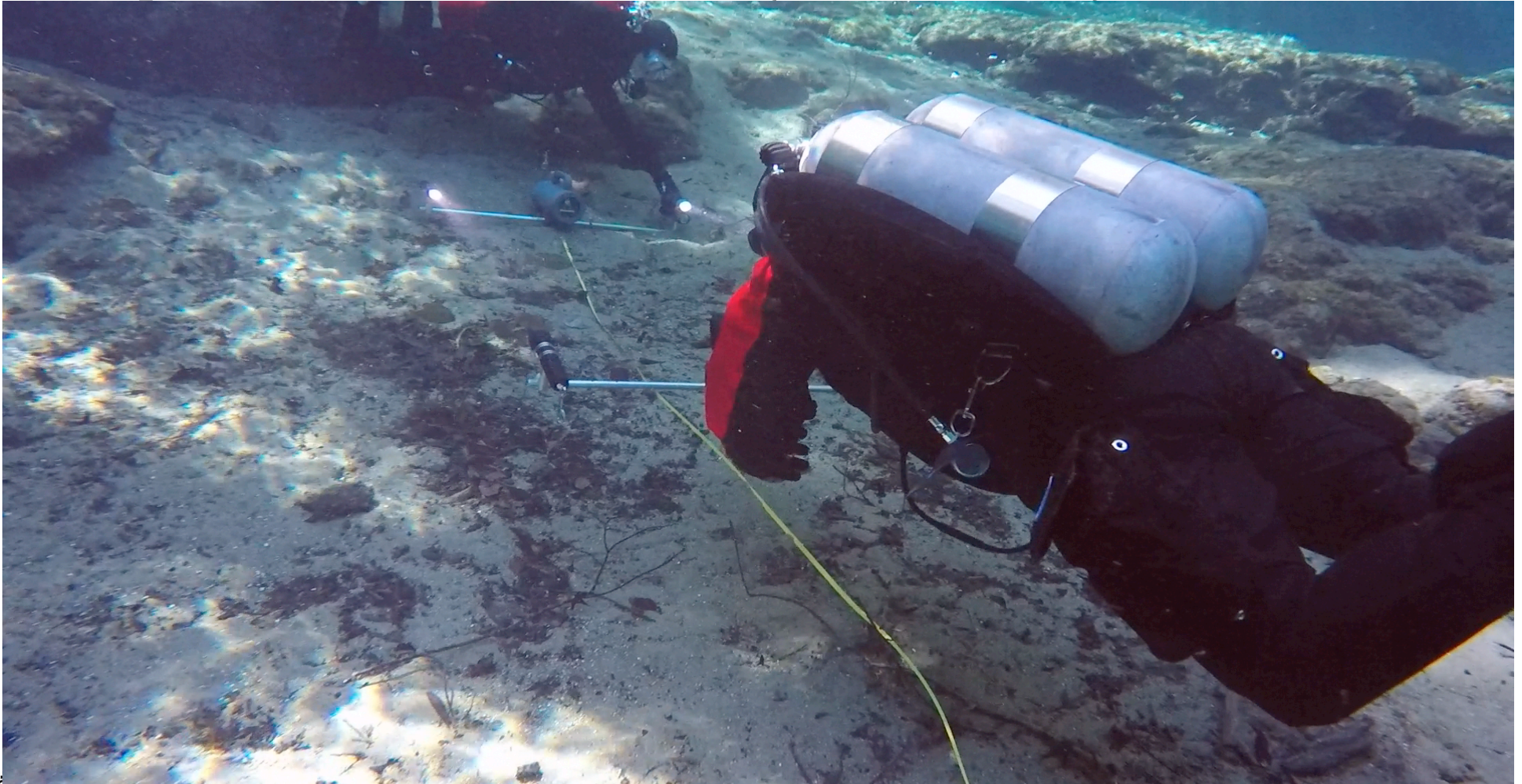# Vehicles

- 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

Cave Mapping using Stereo Vision

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

Underwater Cave Mapping

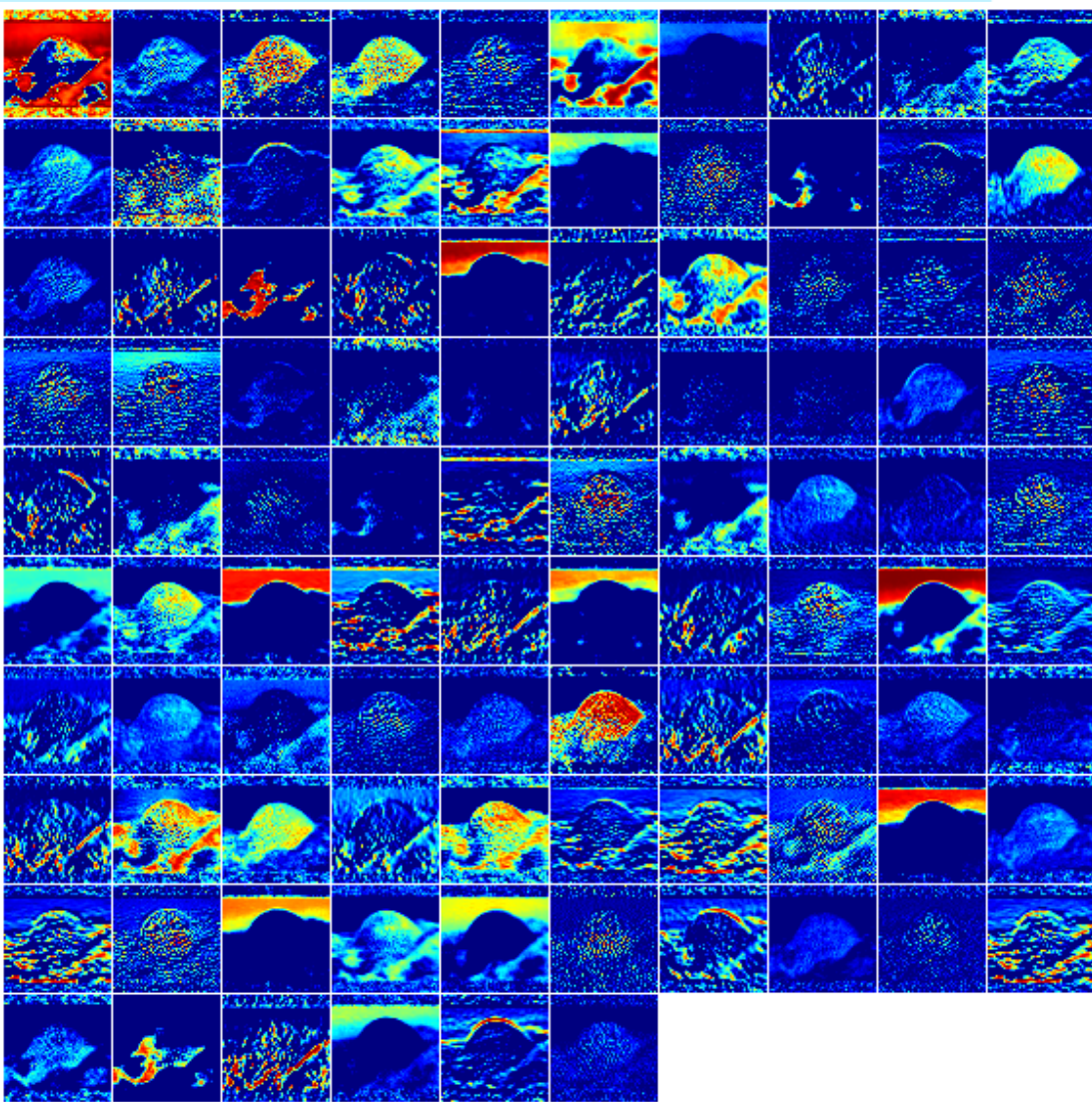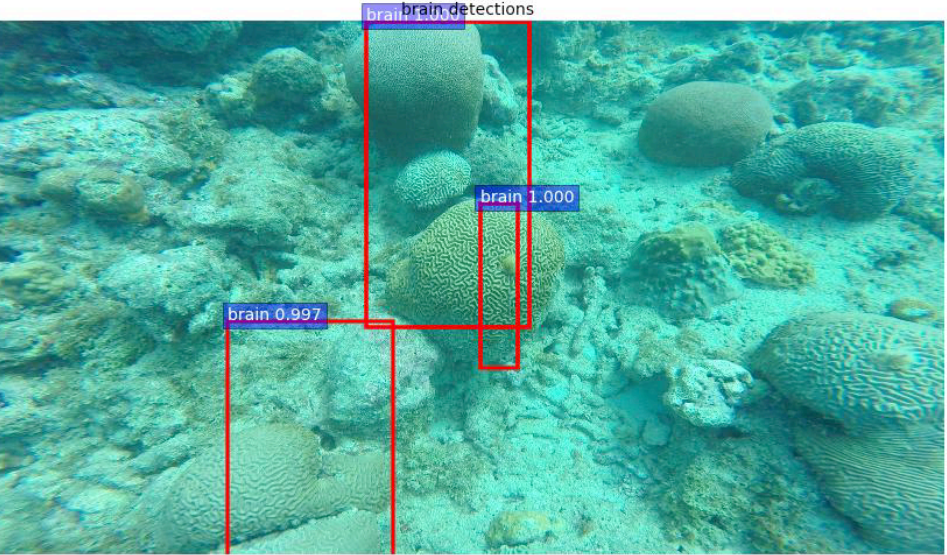Underwater Cave Mapping Using Sonar, Visual, Inertial, and Depth Sensors

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
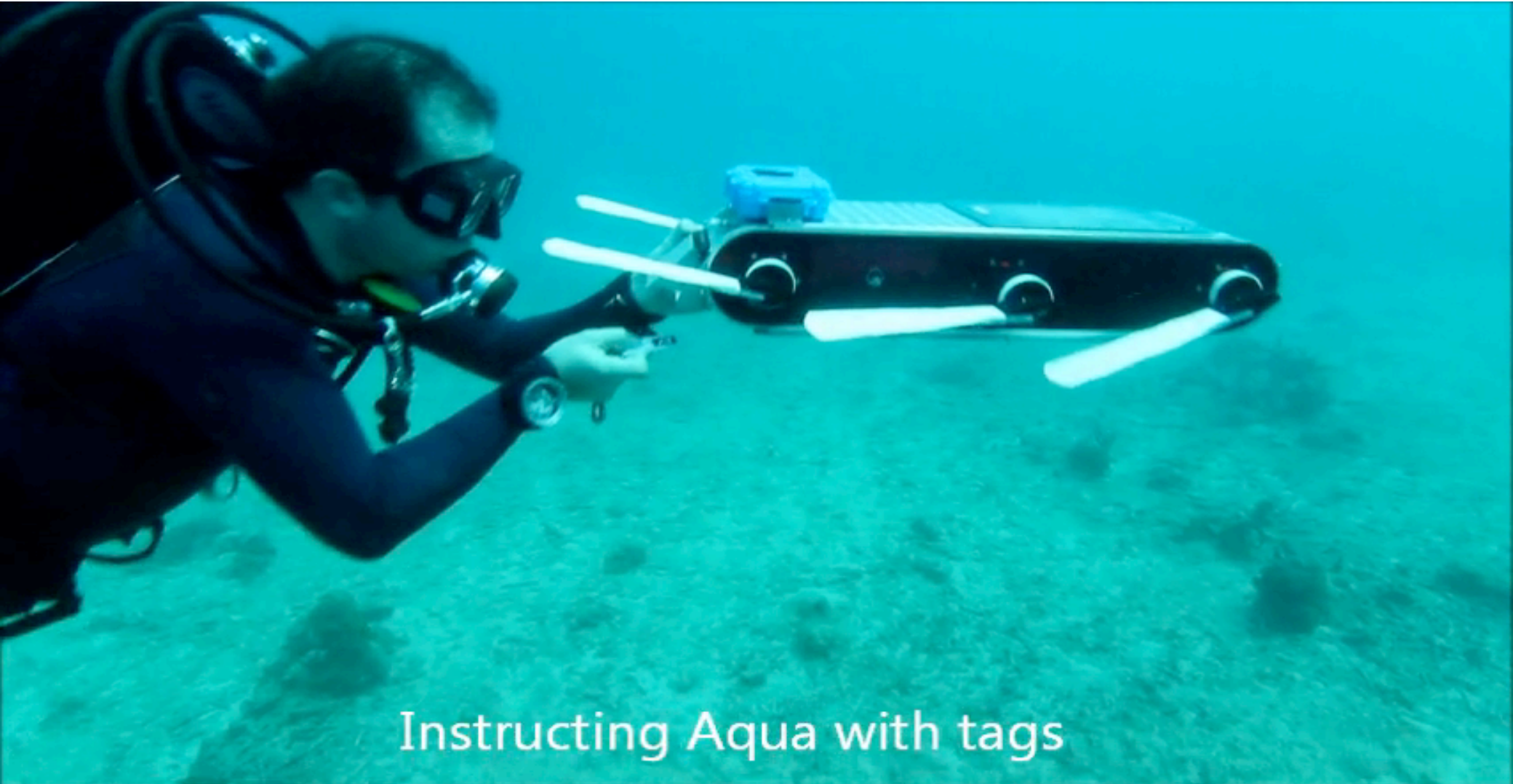# Dubins Vehicle kinematics

Multi-robot Area Coverage with Autonomous Surface Vehicles

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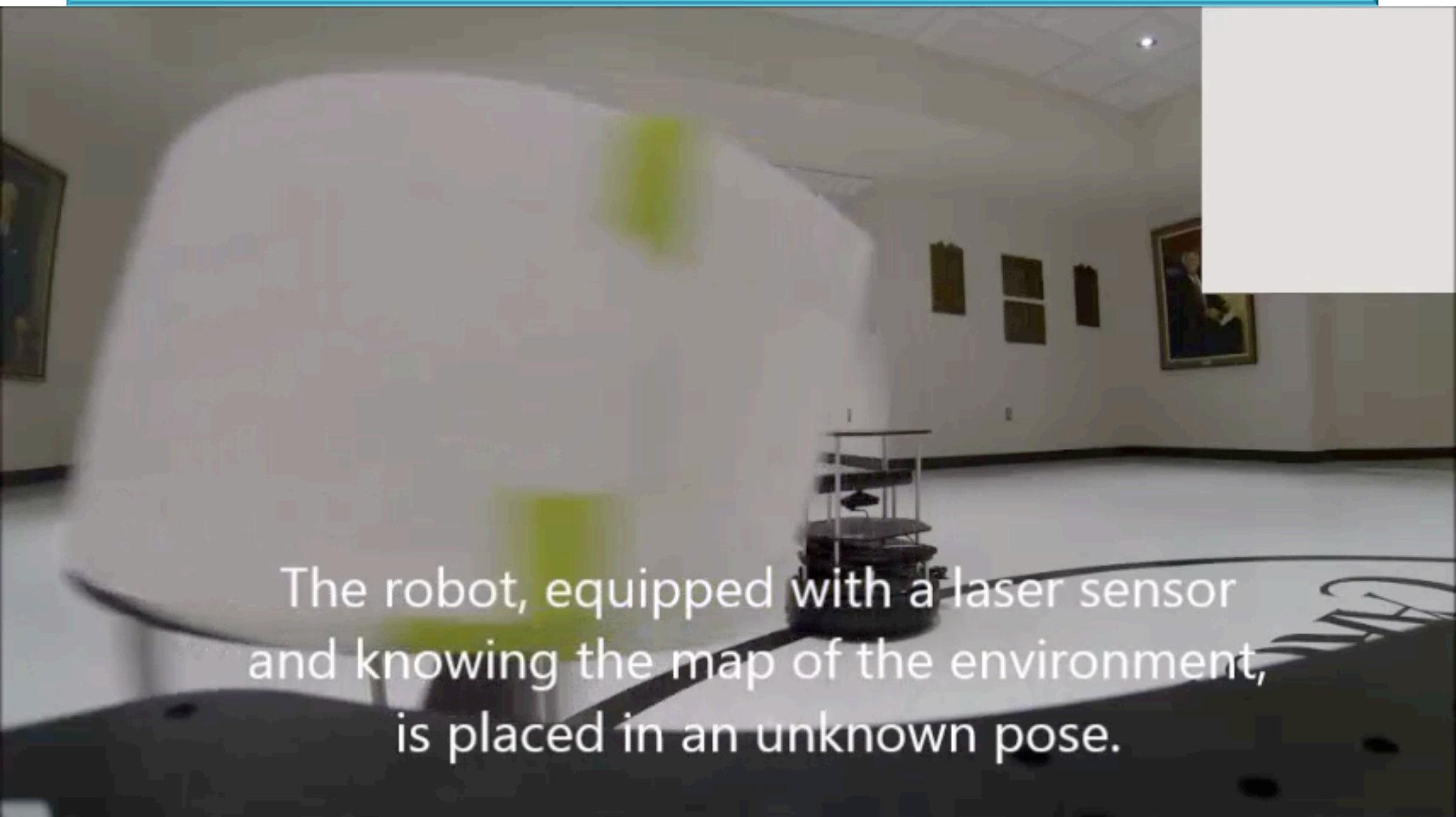Alberto Quattrini Li, Jason M. O'Kane, Ioannis Rekleitis

University of South Carolina

Marine Robotics:
HRI with limited bandwidth
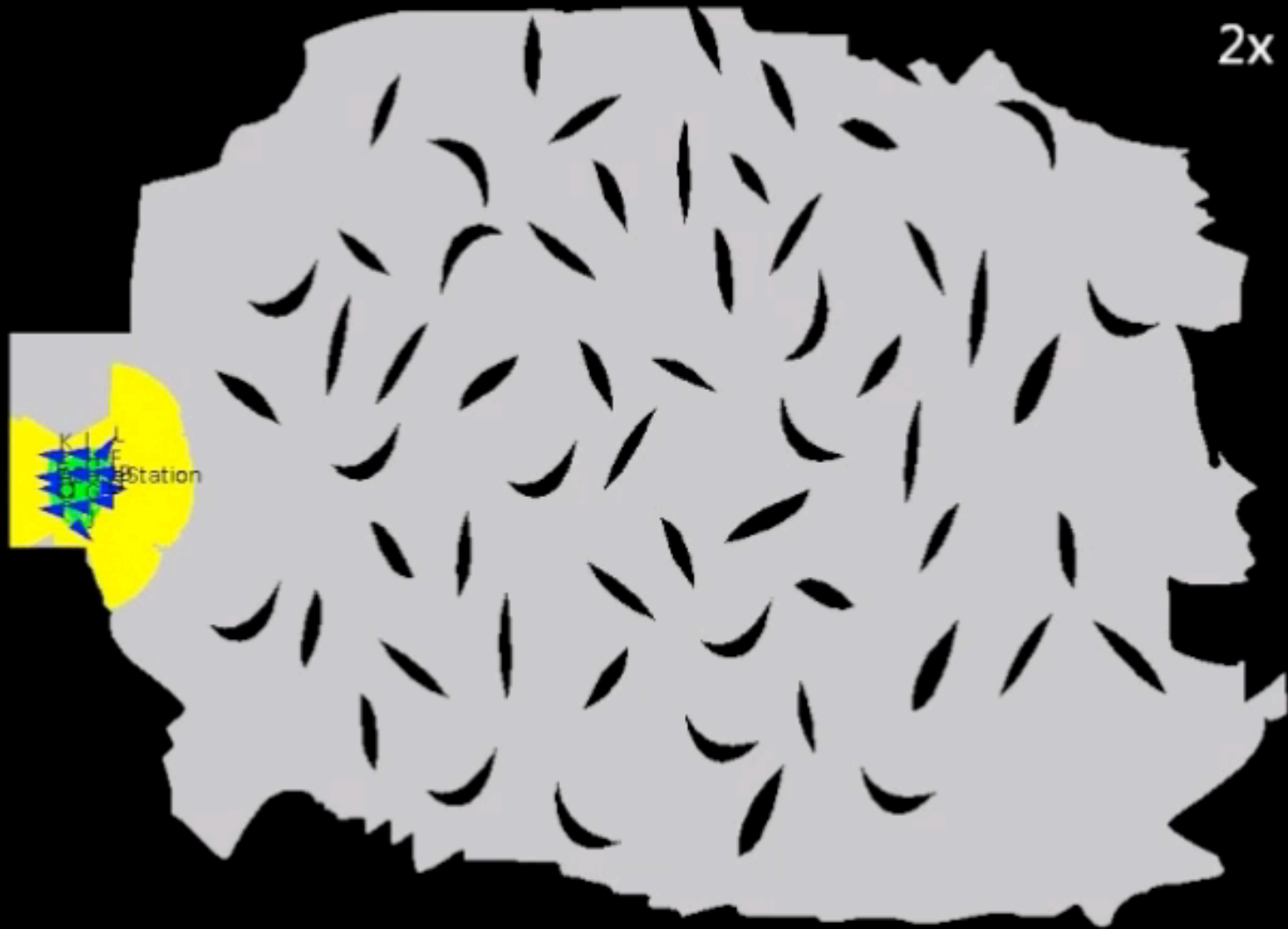

Instructing Aqua with tags

Indoor: Localization with dynamic obstacles

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

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

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- **Email**: yiannisr@cse.sc.edu

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