UNIVERSITY OF SOUTH CAROLINA

CSCE 774 ROBOTIC SYSTEMS

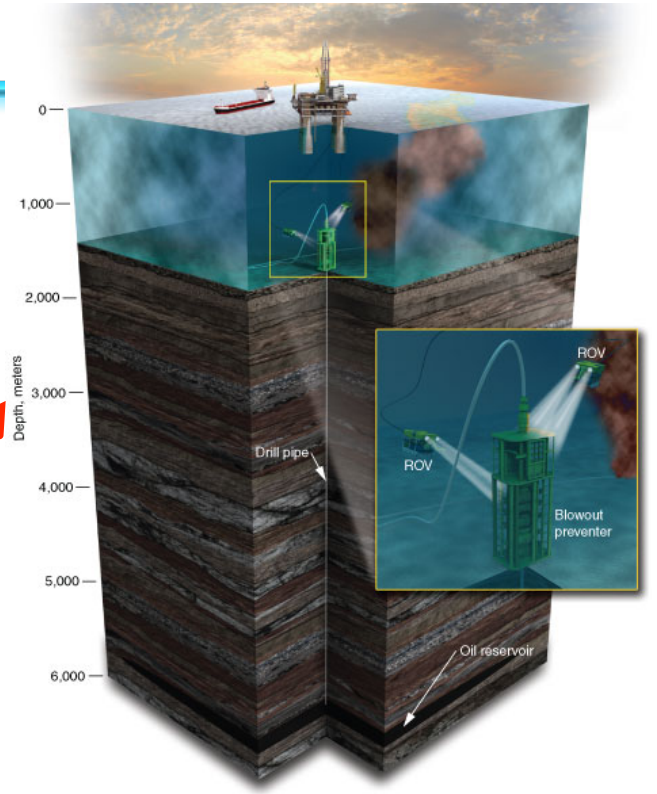
Introduction

Spring 2017

Ioannis Rekleitis

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



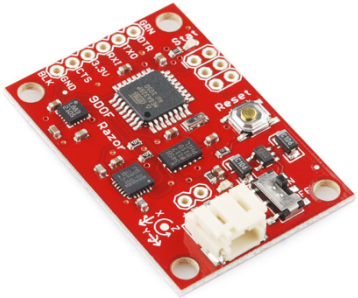
Robotic technology becomes affordable

TurtleBot 2

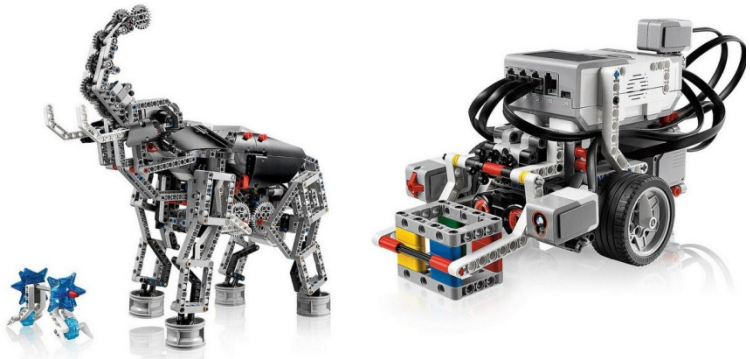
AR.DRONE

Kinect

IMU



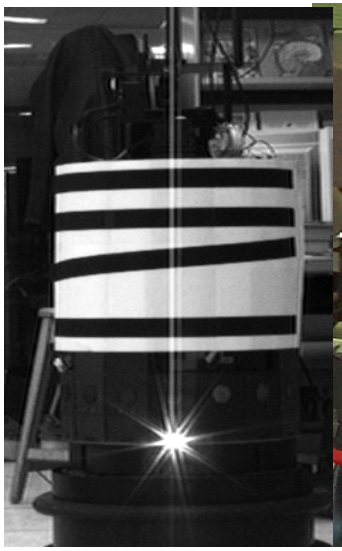
Raspberry Pi

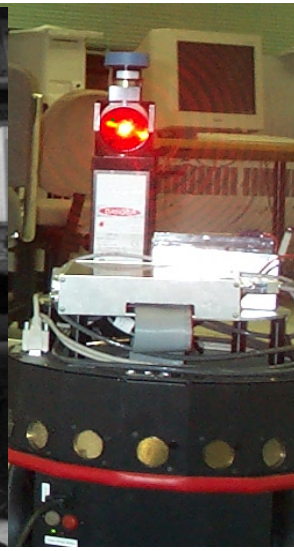


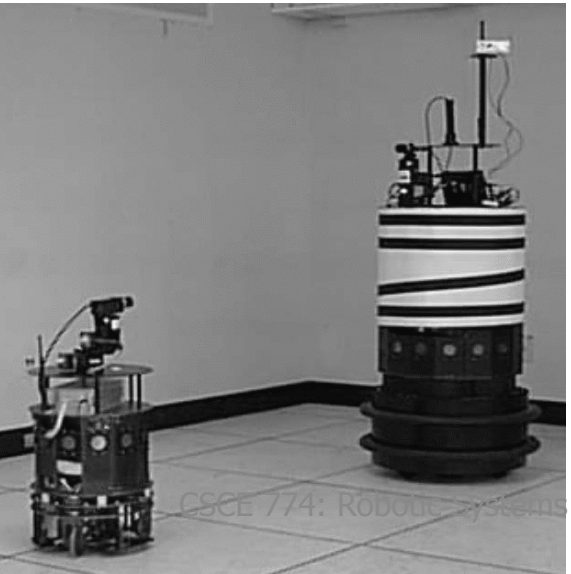
Lego Mindstorm

GPS

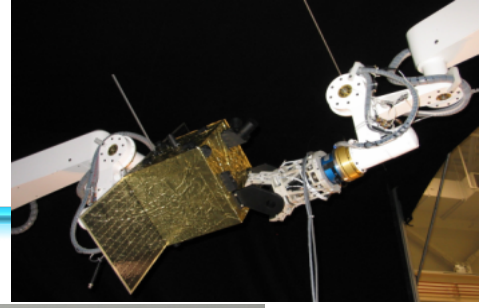
Past Projects







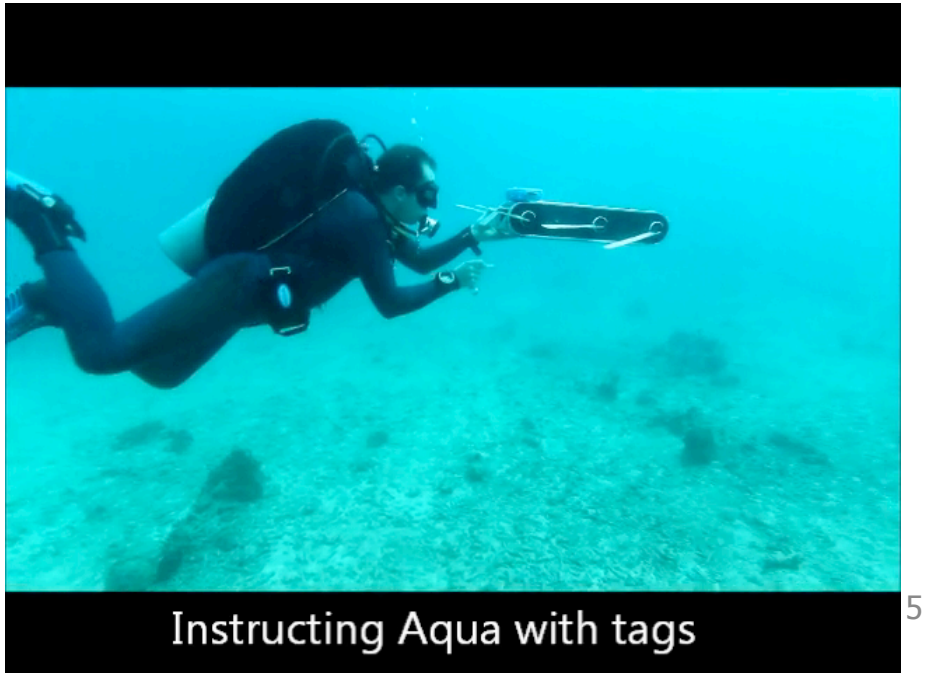
Past/Current Projects



Complete Optimal Terrain Coverage using an Unmanned Aerial Vehicle

Anqi Xu
Chatavut Viriyasuthee
Ioannis Rekleitis

McGill



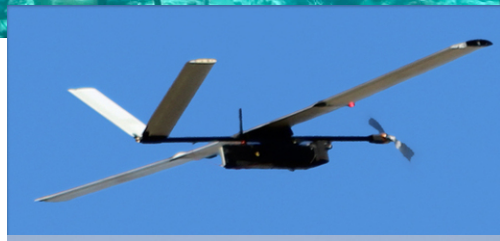
Instructing Aqua with tags

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
- 2015-2018

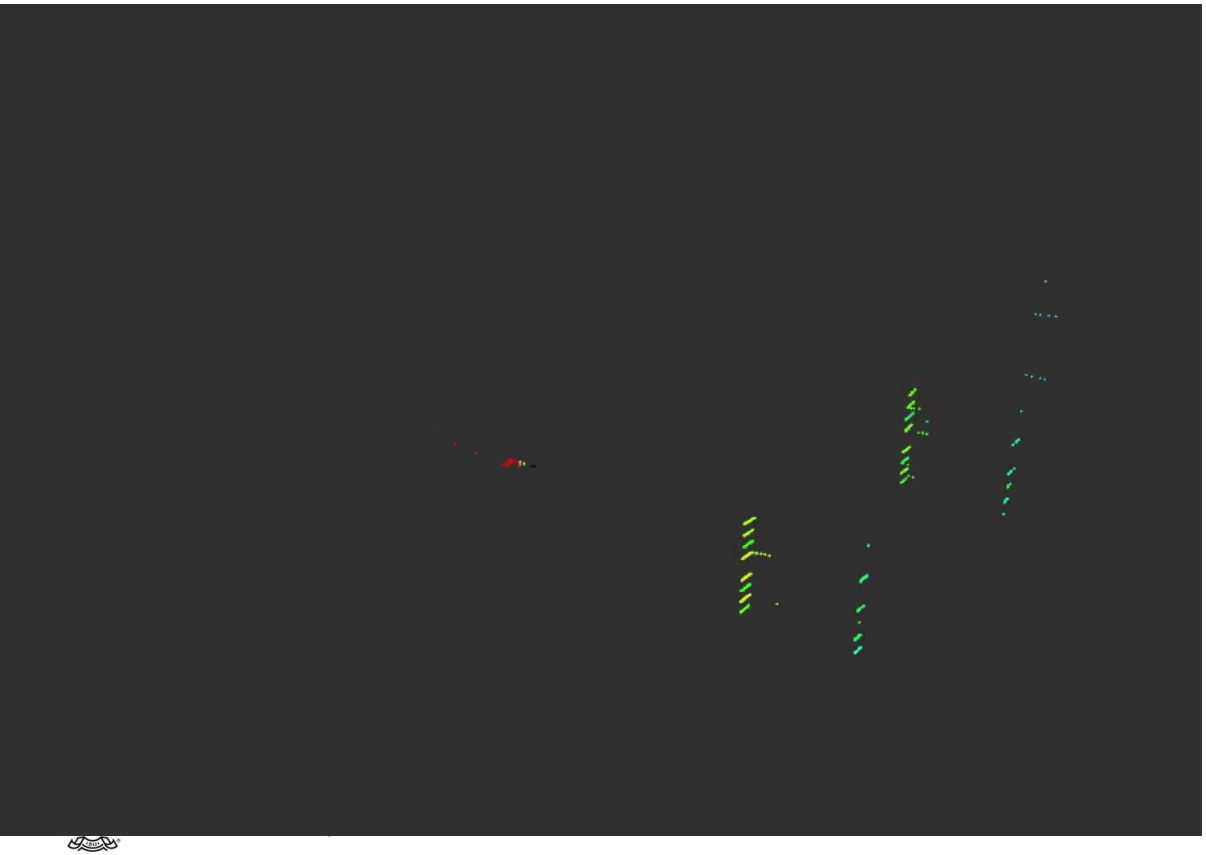
Several Surface Vehicles

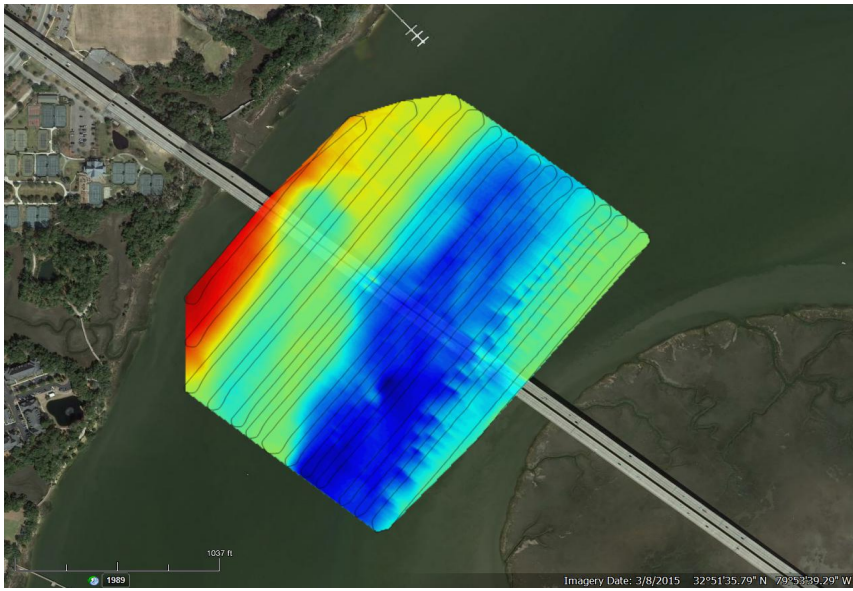
2 fixed wings
2 quadrotor
Aerial
Vehicles



Recent Funding:

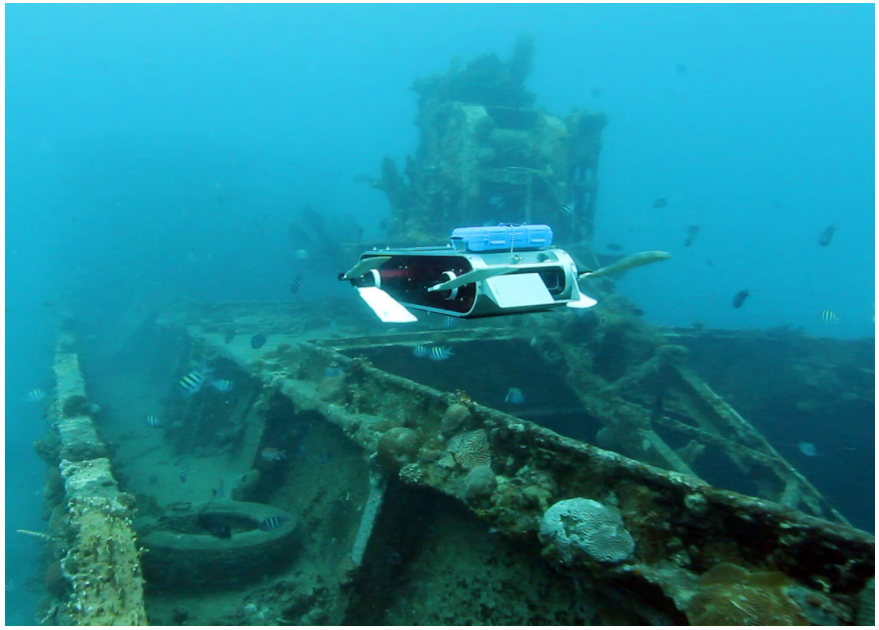
- **SC Floods Research Initiative:** Rapid Assessment of Bridge Scouring and Recovery Following Extreme Flood Events. **PI**: G. Voulgaris

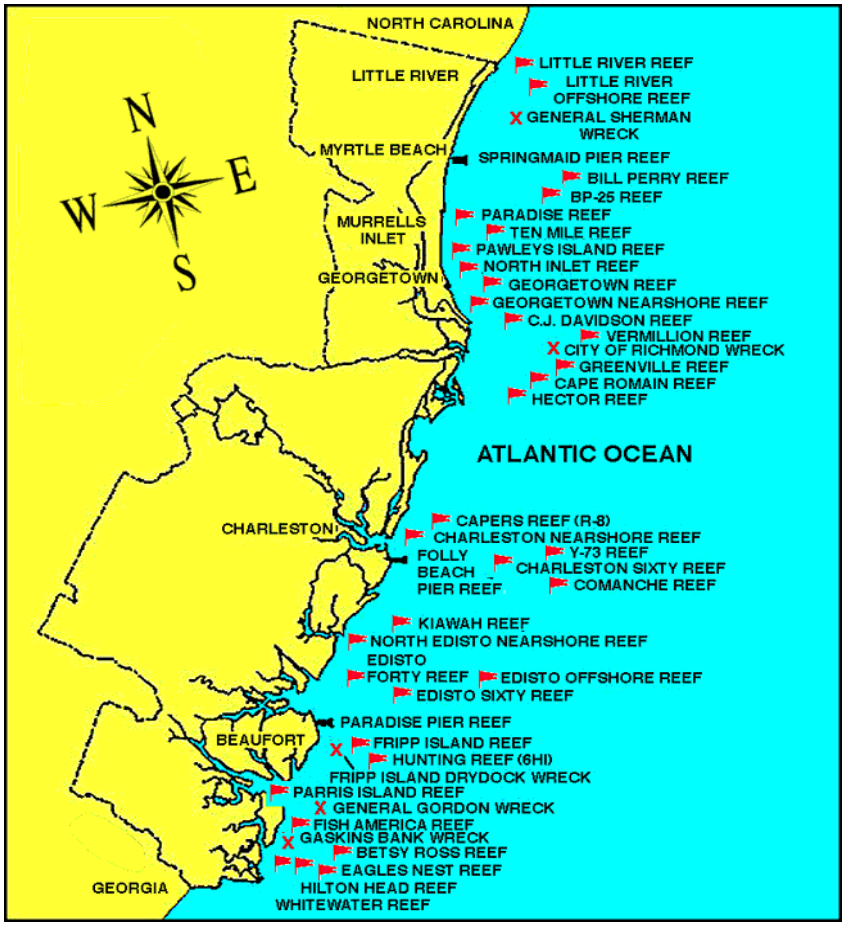




Recent Funding:

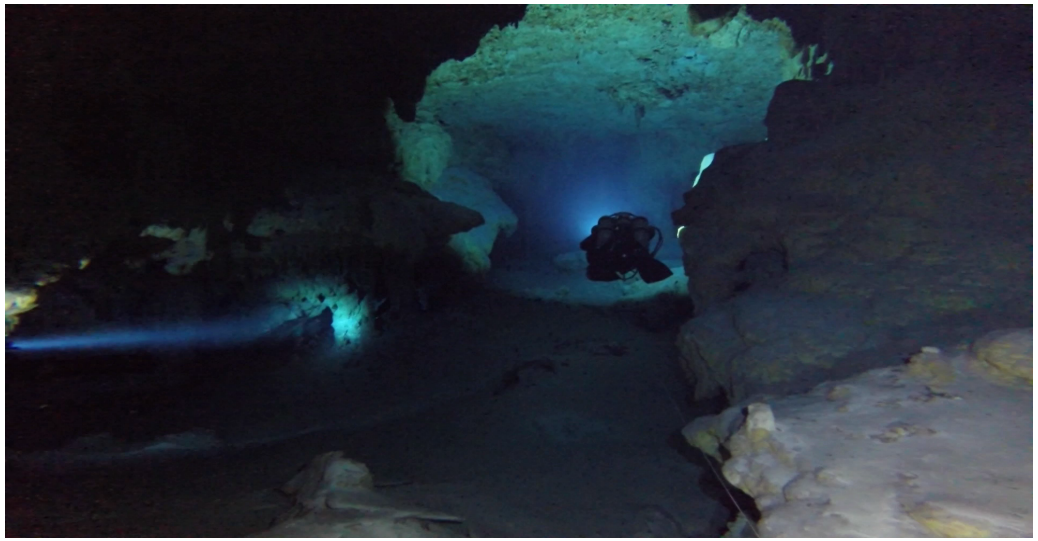
- **Google Faculty Research Awards**: Underwater Street View: Wreck Mapping off the Carolinas
- **PI**: I. Rekleitis
- 2016-2017





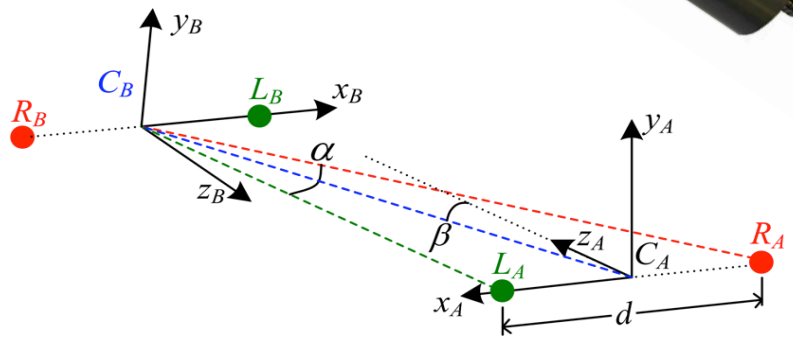
Recent Funding:

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



Stereo Based 3D Reconstruction

SONAR-Vision Fusion



Cooperative Localization

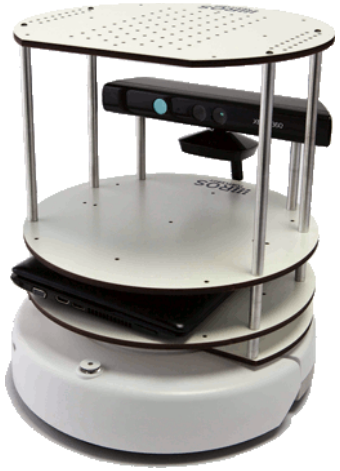
Current work in U/W Robotics

Center for Computational Robotics (CCR)

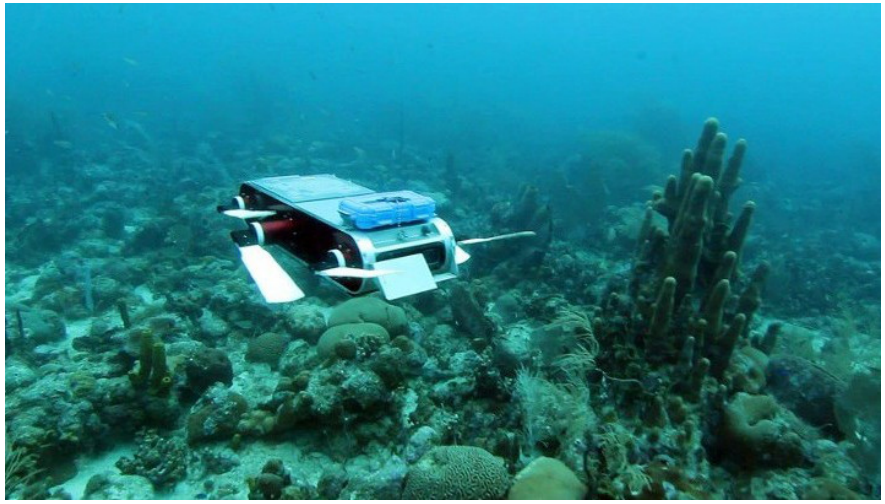
- SCARR lab – Jason O'Kane
- ART lab – Jenay Beer
- AFRL – Ioannis Rekleitis

- AFRL: Autonomous Field Robotics Lab

Existing CCR Robotic Platforms



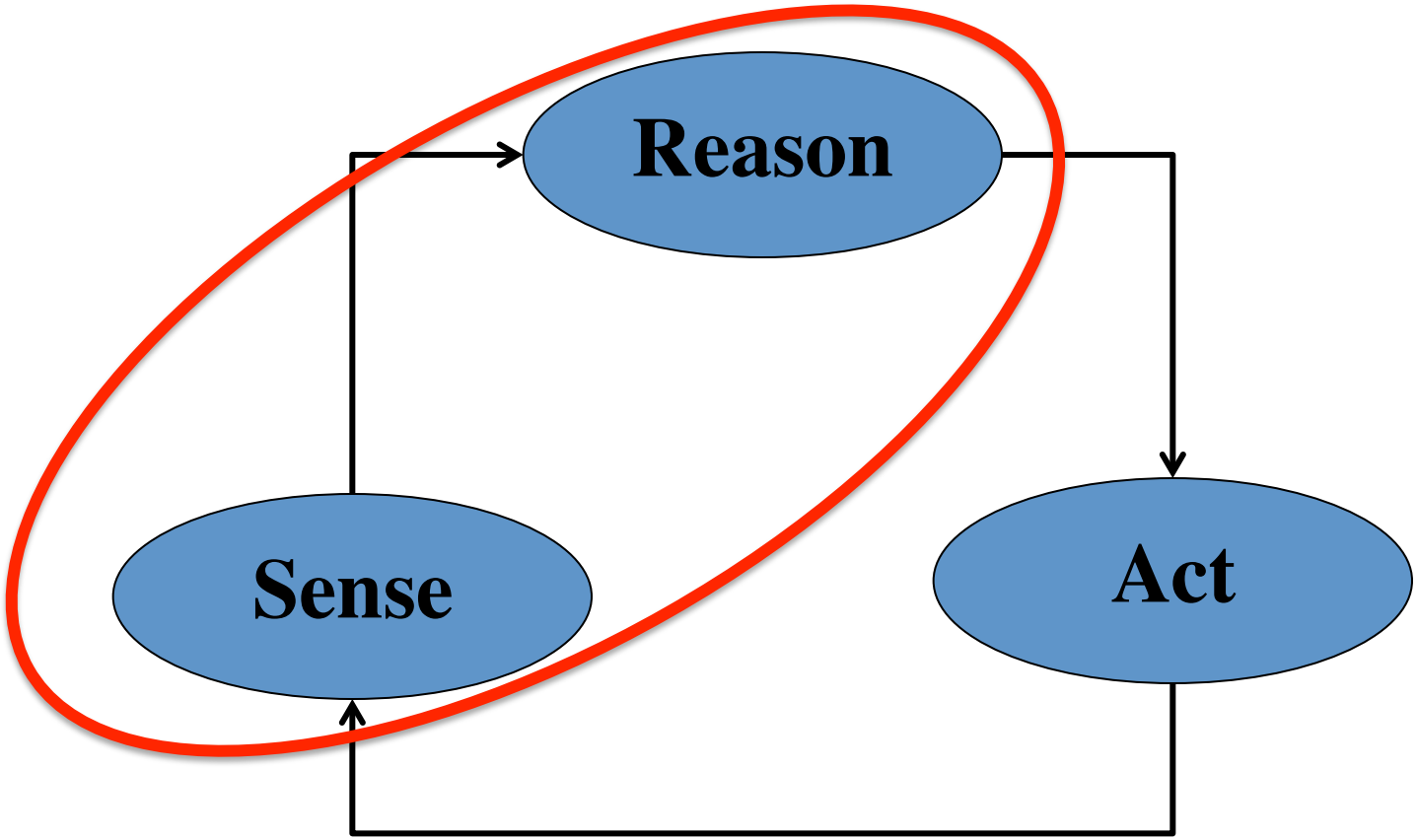
Existing CCR Robotic Platforms



Three Main Challenges in Robotics

1. Where am I? (Localization)
2. What the world looks like? (Mapping)
   - Together 1 and 2 form the problem of *Simultaneous Localization and Mapping* (SLAM)
3. How do I go from **A** to **B**? (Path Planning)
   - More general: Which action should I pick next? (Planning)

Robot



Syllabus

- Focus on **Localization**, **Mapping**, and **SLAM**
- Reading and discussing different research papers
- Presentations by students
- Hands on assignments

Evaluation

- 3 Homeworks, 10% each: 30%
  1. ROS project
  2. Bibliography Search
  3. Vision based state estimation
- Final Project: 20%
- Class Participation: 20%
  - Prepare a small report on each paper/topic
- Presentations: 30%

Homeworks/Projects

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

Possible Papers

1. H. W. Sorenson. Least-squares estimation from Gauss to Kalman, 1970
2. H. Durrant-Whyte and T. Bailey. Simultaneous Localisation and Mapping: Part I, 2006
3. T. Bailey and H. Durrant-Whyte. Simultaneous Localisation and Mapping: Part II, 2006
4. R. Smith, M. Self, and P. Cheeseman. Estimating uncertain spatial relationships in robotic", 1990
5. S. J. Julier J. K. Uhlmann. A New Extension of the Kalman Filter to Nonlinear Systems
6. F. Lu and E. Milios, Globally consistent range scan alignment for environment mapping
7. F. Lu and E. Milios, Robot pose estimation in unknown environments by matching 2d range scans
8. G. Grisetti, C. Stachniss, and W. Burgard. Improved Techniques for Grid Mapping with Rao-Blackwellized Particle Filters
9. D. Scaramuzza, F. Fraundorfer. Visual Odometry: Part I - The First 30 Years and Fundamentals 2011.
10. F. Fraundorfer, D. Scaramuzza. Visual odometry: Part II - Matching, robustness, optimization, and applications. 2012.
11. D. Nister O. Nardoditsky, and J. Bergen. Visual odometry for ground vehicle applications, 2006
12. B. Triggs, P. F. McLauchlan, R. I. Hartley, and A. W. Fitzgibbon. Bundle Adjustment — A Modern Synthesis
13. G. Klein and D. Murray. Parallel Tracking and Mapping for Small AR Workspaces, 2007
14. A.I. Mourikis and S.I. Roumeliotis. A Multi-State Constrained Kalman filter for Vision-aided Inertial Navigation, 2007
15. E. Jones and S. Soatto. Visual-Inertial Navigation, Mapping and Localization: A Scalable Real-Time Causal Approach, 2011.
16. R. Mur-Artal, J. M. M. Montiel and J. D. Tardós. ORB-SLAM: A Versatile and Accurate Monocular SLAM System. 2015
17. M. Cummins and P. Newman. FAB-MAP: Probabilistic localization and mapping in the space of appearance, 2008
18. G. Sibley C. Mei, I. Reid, and P. Newman. Adaptive relative bundle adjustment, 2009
19. M. Milford, G. Wyeth. Persistent navigation and mapping using a biologically inspired SLAM system, 2010
20. C. Forster, M. Pizzoli, and D. Scaramuzza. SVO: Fast Semi-Direct Monocular Visual Odometry, 2014
21. J. Engel, T. Schöps, D. Cremers. LSD-SLAM: Large-Scale Direct Monocular SLAM, 2014.
22. R. A. Newcombe S. Izadi, O. Hilliges, D. Molyneaux, D. Kim, A. J. Davison, P. Kohli, J. Shotton, S. Hodges, A. Fitzgibbon. KinectFusion: Real-Time Dense Surface Mapping and Tracking, 2011
23. S. Thrun and M. Montemerlo. The GraphSLAM Algorithm with Applications to Large-Scale Mapping of Urban Structures, 2006
24. I. Mahon, O. Pizarro, M. Johnson-Roberson, A. Friedman, S. Williams, J. Henderson. Reconstructing Pavlopetri: mapping the world's oldest submerged town using stereo-vision, 2011
25. F. Shkurti, I. Rekleitis, M. Scaccia, G. Dudek. State estimation of an underwater robot using visual and inertial information, 2011
26. R. Kummerle, G. Grisetti, H. Strasdat, K. Konolige, and W. Burgard. G2O: A general framework for graph optimisation, 2011
27. M. Kaess, A. Ranganathan, and F. Dellaert. iSAM: Incremental Smoothing and Mapping, 2008
28. M. Kaess, H. Johannsson, R. Roberts, V. Ila, J.J. Leonard, and F. Dellaert. iSAM2: Incremental Smoothing and Mapping Using the Bayes Tree. 2012
29. M. Montemerlo, S. Thrun, D. Koller, and B.Wegbreit. FastSLAM 2.0: An Improved Particle Filtering Algorithm for Simultaneous Localization and Mapping that Provably Converges, 2003

Contact

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- **Office hours**: 3A54 -- Tue/Th 13:00-14:00
  and by appointment

Class Interests

Please email me with a two/three paragraphs talking about:

- Introduction
- Background
- Interests
- Projects
- Reasons
- Expectations