



Robotics Systems Laboratory

Field robots/systems for land, sea, air and space

- Complex, software-enabled electromechanical systems
- Involvement ranges from design through field operations
- Professional clients/sponsors (government, industry, non-profits)
- Several million dollars of active R&D projects involving graduate and undergraduate students





Robotics Systems Laboratory

Typical majors

- Mechanical, Computer and Electrical engineering
- Depending on the project, have also worked with bio-engineers, civil engineers, science students, etc.

Typical activities/skills/interests

- Mechatronics, control systems, embedded systems
- IoT, wireless communications, power systems, and circuit design
- Programming, algorithms, automation, perception (vision, ML, etc.)
- Structural design, machine design, fabrication
- Systems engineering, design thinking, product design

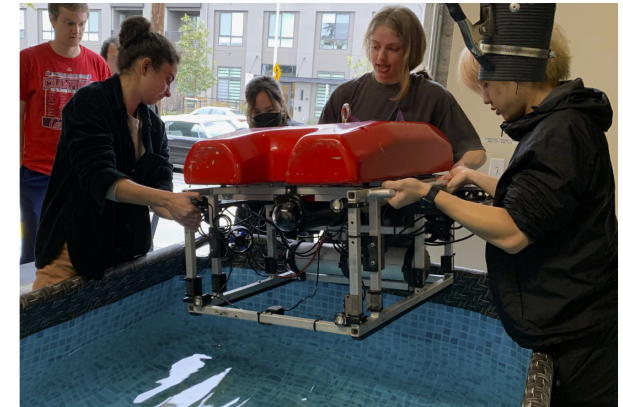
The following slides showcase some current project opportunities – other opportunities exist



Nautilus Underwater Robot: Advanced Manipulator System



- **Nautilus Marine Robot**
 - Used for exploration of Lake Tahoe and Monterey Bay
 - Students design capabilities/tools and deploy in water
 - Serves customers from US Geological Survey, Monterey Bay Aquarium Research Institute, NOAA, and others
- **Robotic Manipulator Development**
 - Current effort focuses on a 3DOF arm and soft gripper
- **New Opportunity** – Explore advanced robot arm capabilities
 - New tools for grasping objects, collecting silt, taking core samples from ocean floor and sunken trees (for carbon dating), retrieve artefacts
 - Advanced arm control: haptic feedback, vision-based servo-ing, coordinated vehicle/arm control
 - Demonstrate capabilities in Lake Tahoe geology mission with USGS



Nautilus Robot

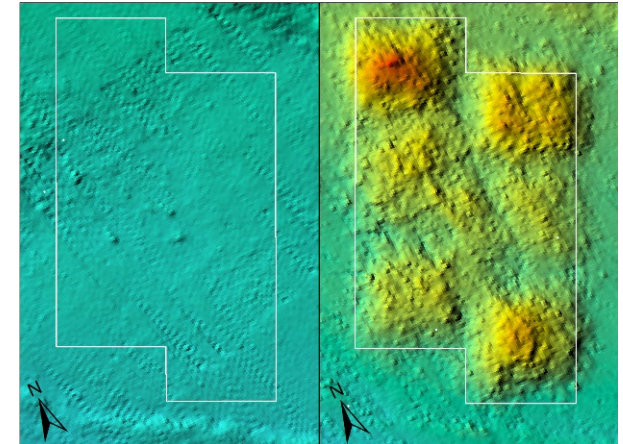


RSL Boat in Lake Tahoe



Artificial Reef Sensor Network

- **Palos Verdes Artificial Reef**
 - Artificial reef installed by NOAA as part of restoration program to restore fish habitats and establish substrate for kelp, algae and marine invertebrates
 - Monitored routinely via SCUBA divers through marine science program at Occidental College
- **Opportunity** – Infuse marine sensing technology to enhance reef monitoring
 - Design a “benthic observatory” with cabled sensor nodes and shore communications
 - Design mobile robotic “diving vertical profilers” with automated surface navigation
 - Install technology at reef and launch automated monitoring services



Constructed Reef, 2020



Reef quarry rock with SCUBA diver taking measurements



Aerial Drones w/Physical Interaction



- **Physical infrastructure services**
 - RSL has initiated work with one of the US's largest infrastructure companies
 - Using piloted drones to inspect poles/towers – but would like extend capabilities to services with physical interaction, such as installing/retrieving equipment, cleaning, etc.
- **Opportunity** – Develop ability to install self sealing pole-caps and/or sensor packages via drone
 - Explore vision-based pilot aids for automated alignment, mating, installation, retrieval
 - Design mechatronic self-sealing cap device
 - Rigorously test system, train pilots and transition to field services



Heavy Lift Drone w/Payload



Hundreds of concrete utility poles require capping to prevent corrosion



Automated, Ocean-based Drone Landing Platform



- **Marine science systems**

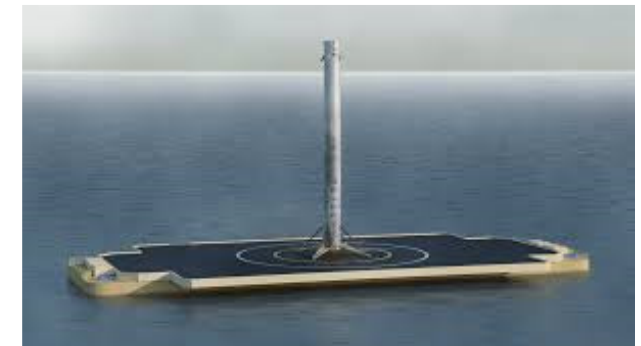
- RSL has a longstanding collaboration with the Monterey Bay Aquarium Research Institute (MBARI), involving the development of advanced marine technology
- MBARI has started a drone program for aerial ocean monitoring – requires a marine landing platform

- **Opportunity** – Develop an automated surface vessel to serve as a drone take-off and landing platform (10'x10' or larger)

- Develop a new – or adapt an existing – automated boat capable of GPS-based navigation and station-keeping
- Boat should have wave damping features, battery power, wireless communications, etc.
- Test platform in lakes and in Monterey Bay



Current automated RSL boat with wave damping – could be retrofitted



SpaceX does it for rockets – nobody's done it for drones!



Agricultural Rover: In-field crop tools/systems



- **Agricultural Robotics**

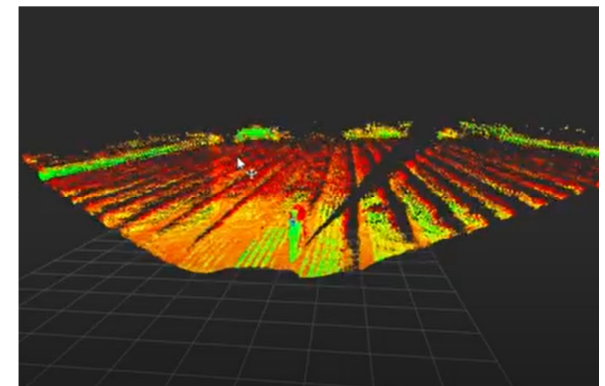
- RSL has developed several modular ag-bots with auto-navigation modes – can host application-specific tools
- Robot is being routinely tested at local Jacobs Farm and will soon begin testing at Kings Mountain Winery

- **Opportunity** – Develop application tools for partner growers. Options:

- Spray system with ultra-high spatial precision
- Combination blower/vac for blowing moisture off plants and removing bugs from field
- Remote, soft harvesting via teleoperation
- Evaluate system in the field and – if robust – begin routine use with local growers



Modular RSL AgBot



LIDAR sensing of field



Mission Control Environment

- **RSL Mission Control**

- RSL conducts mission control services for a range of sponsors and applications, such as control of NASA spacecraft
- We are interested in using the free COSMOS software environment, from Ball Aerospace, and developing a suite of complementary systems/tools for a variety of uses

- **Opportunity** – Develop a suite of mission control capabilities exploiting COSMOS as the main data “plumbing” software

- Learn/install COSMOS, integrate d/b and analytics capabilities
- Create advanced capabilities for fault diagnosis, experimental sequencing, etc
- Evaluate via mission control operations for the NASA ACS3 spacecraft & other remote systems



Telemetry Display from COSMOS Mission Control Software



NASA ACS3 Spacecraft, which RSL will control once launched



Cobot Applications

PENDING

- **Cobot Systems**

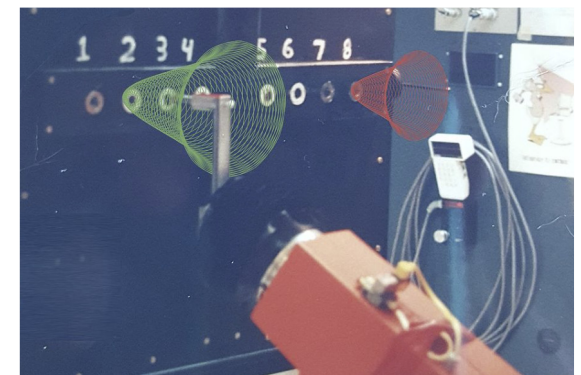
- RSL has a number of robotic arms, both conventional industrial robots as well as the new class of “cobot” arms, which allow close-proximity human interaction
- We have several capabilities of interest, involving immediate and future industrial applications with several corporate partners

- **Opportunity 1** – Develop a cobot “kitting” system to sort, pick, and package hardware (bolts, washers, brackets, etc.) for a major manufacturing company

- **Opportunity 2** – Develop an advanced Augmented Reality interface for collaborative human-cobot object manipulation, using virtual fixtures, etc.



Cobot pick and sort



AR Virtual Fixture for Assistive Manipulation



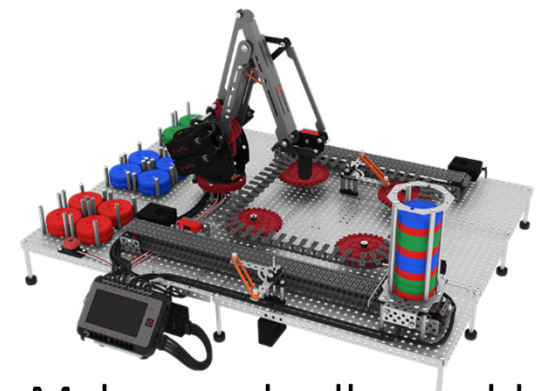
Maker Innovations



- **Maker Lab / Equipment Innovations**
 - SCU was one of the first universities with a significant maker lab program and has helped dozens of other institutions to launch their labs/programs
 - There is a continuing desire to be a leader and innovator in this space, introducing new machines and capabilities
- **Opportunity 1** – Develop new consumer-class electroplating maker tool
 - Project would include development, DfM, prototyping, market analysis, etc. Kickstarter?
- **Opportunity 2** – Develop a maker workcell capability with automated workflow
 - Identify candidate application, adapt and integrate multiple tools to support automated production



Turn this beast into an easy-to-use, cost-effective consumer product for the maker community



Maker workcell – could include adapted 3d printer, laser cutter, arm, etc.