

Title: Robots in Harsh and Unstructured Environments

Organizers: [Mihai Duduta](#), [Alberto Quattrini Li](#)

September 25, 3:30 pm - 5 pm

Location: 17th Floor | Room: Allegheny

Description

Deploying autonomous systems in extreme terrestrial, marine, subterranean, and planetary domains requires a tight integration between physical mechanics and intelligent decision-making. This workshop explores recent advances at the intersection of robust hardware design and adaptive autonomy for robots operating in harsh, unstructured environments. Featuring invited talks from leading field robotics researchers across diverse domain axes—from deep-sea and marine vision to space dynamics, dynamic legged locomotion, modular mechanisms, and field planning—the session will cover end-to-end design strategies for resilient robotic systems. The workshop will conclude with lightning presentations from early-career/aspiring PIs and an interactive panel discussion on key open challenges in field deployment.

Agenda

3:30 pm - 3:40 pm

Mihai Duduta and Alberto Quattrini Li

Welcome and Introductions

3:40 pm - 3:50 pm

Invited talk by [Eleonora Botta](#) (University at Buffalo)

Title: Robotic Interaction with Uncooperative Targets: Lessons from Cable-Based Space Debris Removal

Abstract: Robotic systems operating in harsh and unstructured environments must often interact with targets whose properties and state are only partially known. Manipulation is especially challenging when the targets are uncooperative and offer no dedicated interfaces for capture. This presentation explores these issues through the lens of cable-based space robotics. Compared to traditional robotic systems, cable-based systems allow interaction from a larger distance and increased compliance to the target shape, making them attractive for the capture of tumbling uncooperative objects. However, they introduce challenges in simulation and control due to their flexible and highly coupled dynamics. Drawing on recent research in the capture and manipulation of space debris, the talk highlights key considerations in dynamic interaction, uncertainty management, and autonomous decision-making. Broader insight is drawn for robotics in extreme environments involving uncertain and dynamic targets.

3:50 pm - 4:00 pm

Invited talk by [Aaron Johnson](#) (Carnegie Mellon University)

Title: Robots Digging in Dirt

Abstract: How do we enable better locomotion in and manipulation of dirt, sand, and vegetation? We don't have good models of these environments, making it hard to use model based or learning based approaches that depend on having high fidelity models. However, the robot must be careful to make sure it does not get stuck while still accomplishing its goals. In this talk I will present three recent projects: 1) An environmental monitoring robot for finding contaminated

soils. 2) Terramechanics models for nonprehensile terrain manipulation with a wheeled rover. And, 3) Quadrupedal locomotion through vegetation and mud.

4:00 pm - 4:10 pm

Invited talk by [Geoffrey Hollinger](#) (Oregon State University)

Title: Do we need the ship and the operator? Autonomous underwater docking, recharging, and manipulation

Abstract: Underwater gliders, propeller-driven submersibles, and other marine robots are increasingly tasked with information gathering and manipulation tasks (e.g., ecological monitoring, offshore inspection/repair, and coastal surveillance). However, in most existing scenarios, human operators must carefully plan the mission or fully teleoperate the vehicle to perform the task. To remove these limitations, we can move toward underwater robotic systems that achieve ‘residency’ by existing in the underwater environment for long periods of time without ship support and human oversight. To help achieve this goal, I will discuss how our learning and planning architectures enable autonomous docking and recharging of underwater vehicles with Wave Energy Converters (WECs). In addition, I will show how autonomous manipulation is possible in challenging underwater environments by leveraging deep learning for grasp synthesis and sonar/camera fusion. Taken together, these contributions move us toward achieving both autonomy and residency in underwater robotic systems and drastically reducing the cost of operations and maintenance in underwater applications.

4:10 pm - 4:20 pm

Invited talk by [Corina Barbalata](#) (Louisiana State University)

Title: Adaptive Autonomy for Marine Robots in Coastal Environments

Abstract: Marine robots have gained research attention over the past years, as they can be used to explore and monitor the oceans and to perform tasks in environments that are dangerous, inaccessible, or challenging for humans. Limited communication, uncertain dynamics, degraded visibility, strong environmental disturbances, and constrained energy resources make reliable operation difficult, especially robots deployed for long periods without human intervention. Yet marine robots have the potential to expand our ability to explore, monitor, and interact with the oceans while performing tasks that are dangerous or inaccessible to humans. This talk will provide an overview of recent works of my group towards enabling autonomous marine robots to operate reliably in such challenging environments. The talk will briefly present results from our stochastic modeling for capturing uncertainty and variability in marine systems, model-based control for improving prediction and robust operation, and environmental perception for enabling robots to understand and respond to their surroundings. These approaches are being applied to marine robotics projects addressing challenges such as coastal monitoring, environmental data collection, and water-quality assessment.

4:20 pm - 4:30 pm

Invited talk by [Howie Choset](#) (Carnegie Mellon University)

4:30 pm - 4:40 pm

Aspiring PI talks

- [Boyuan Chen](#) (Duke)

Title: Adaptive Embodiment for Unstructured Worlds

Abstract: Robots operating in harsh and unstructured environments cannot rely on fixed assumptions about how they should sense, move, or interact with their surroundings. Our work explores a full-stack approach to designing sensing, embodiment, and control together to create robots that adapt to environments beyond those anticipated at design time. I will highlight recent examples ranging from unconventional multimodal sensing to reconfigurable and morphology-aware robots. These efforts point toward robots whose physical intelligence emerges from the joint design of perception, morphology, and behavior.

- [Mingi Jeong](#) (Virginia Tech)

Title: Toward Reliable Autonomy in Dynamic Aquatic Environments: From Perception to Decision-Making

Abstract: Robots operating in aquatic environments must contend with sparse and uncertain perception, dynamic interactions with other agents, and environmental disturbances that are difficult to model in advance. My research develops perception and decision-making frameworks that enable autonomous surface vehicles to operate robustly under these real-world uncertainties. I will briefly highlight our work on maritime situational awareness, intention-aware collision avoidance, and risk- and efficiency-aware route planning, together with field-deployed robotic operations in which these algorithms are designed and validated in natural aquatic environments. These efforts motivate my broader research vision: developing autonomous robots that can reason about the reliability of their perception, interactions, and environmental models while adapting their decisions online, and extending these capabilities to heterogeneous multi-robot systems that can coordinate across complementary platforms in dynamic and unstructured environments.

- [Nare Karapetyan](#) (WHOI)

Title: Algorithmic Field Robotics

Abstract: The marine environment is one of the most fascinating and challenging environments, with many undiscovered areas and species. To understand these environments, autonomously operating robots and agents provide unprecedented opportunities. However, the real world poses challenges that these systems must overcome, including environmental uncertainties, limited communication, changing conditions, and unreliable sensor readings. At the same time, although multi-agent systems can increase the scale of operations, they also drastically increase the complexity of the problem, especially when heterogeneous systems are used. This talk will explore algorithmic solutions that can be applied hierarchically to solve coverage

planning and exploration problems. By exploiting the geometric properties of environmental structures and task-specific sensing requirements, we present approaches that generate high-level coverage plans while adaptively collecting information about regions of interest. We show how vision-based navigation approaches can generalize across applications, from shipwreck exploration and oyster reef monitoring to wildlife monitoring. Ultimately, our goal is to build heterogeneous multi-agent systems that can efficiently monitor environments and adapt to changing conditions.

- [Monika Roznere](#) (Binghamton)

Title: How can we enable accessible robots to work in unmapped and poorly understood environments?

4:40 pm - 5:00 pm

Panel discussion with invited speakers