The Robomechanics Lab

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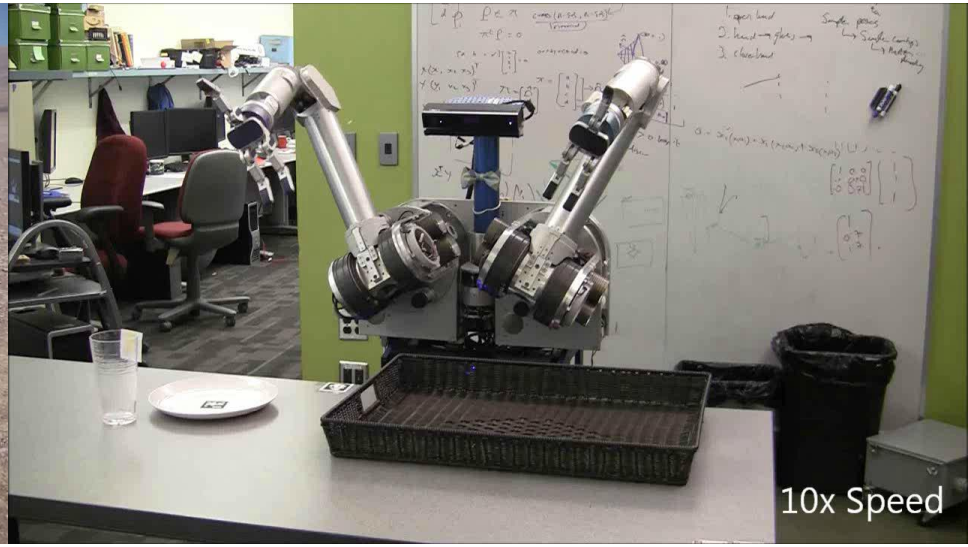
Goal: Robots that can work in the real world

Wilderness/Planetary Exploration



Home

Environmental Monitoring

Industrial Inspection

C. Pavlov and A. M. Johnson. "Soil Displacement Terramechanics for Wheel-Based Trenching with a Planetary Rover." *ICRA*, 2019.
S. Srinivasa, et al. "A System for Multi-step Mobile Manipulation: Architecture, Algorithms, and Experiments." *ISER,* 2016.
J. Norby, et al. "Path to Autonomous Soil Sampling and Analysis by Ground-Based Robots." *J. Environmental Management*. 2024

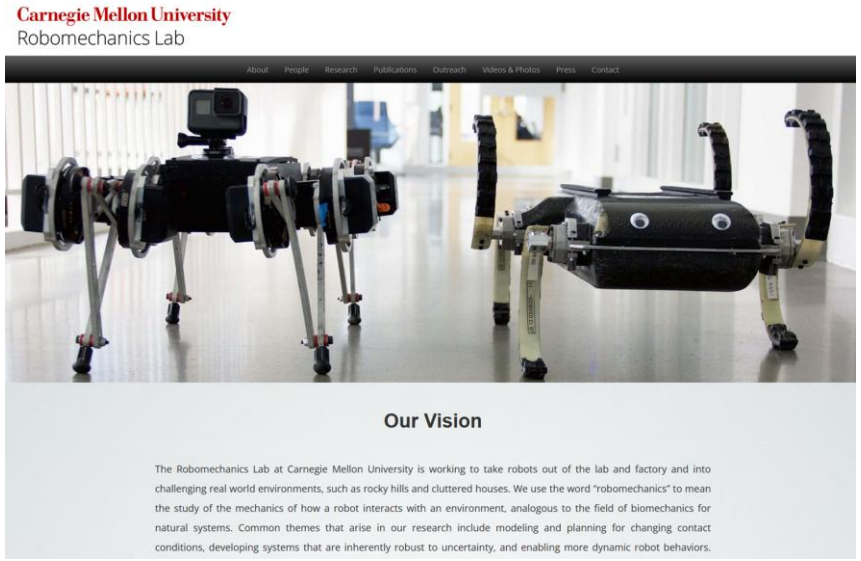
Problem: The World is a Mess

Robot Locomotion Challenges

Unexpected contact with the world

Lab Overview

Lab

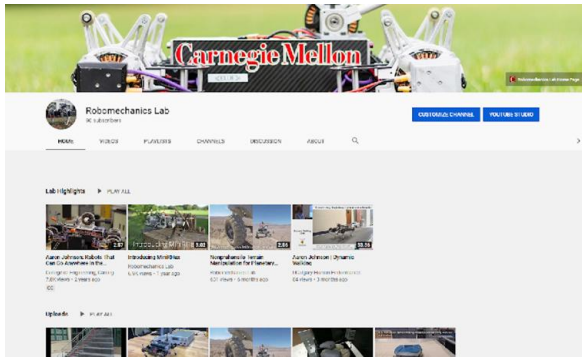


With research overview, recent publications, etc
https://robomechanics.net

YouTube Channel with more talks and research videos:
https://www.youtube.com/channel/UCKD78aZAsdB9-JTwrt6Q1KA

Recent Seminars:

https://www.youtube.com/watch?v=KVjeNPxD0DE
https://www.youtube.com/watch?v=GHXko5-CorQ



Where is Prof. Johnson?

- Munich, Germany
- Prof. Johnson is on sabbatical for the 2025-2026 school year
- BUT, we are still taking new students for projects
- He will be joining meetings and available for 1:1 over zoom

Fall 2025 Projects

robomechanics.net
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- I am an MS-R or CIT-H student. How do I work with you?
  1. Look through this document at the advertised projects.
  2. Read the recommended paper.
  3. After that, email Prof. Johnson with:
     - Your resume
     - Which project you are interested in
     - Why you want to work on that project (~2 sentences)

- Do you advise MS-C, MS-AS, or other non MS-R students?
  - Yes, but priority is for MS-R slots first.

- Do you fund MS-R students?
  - No. I wish I could!

Project 1: Adaptive Learning Control

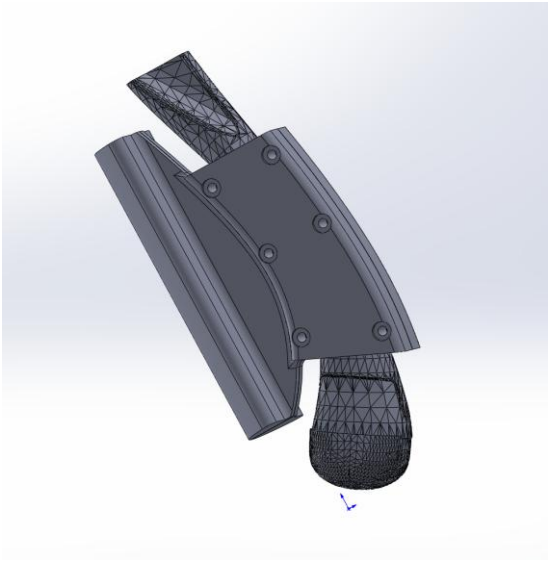
- Improving adaptability of learned control systems
- Applications on legged robots and construction vehicles
- Integration with perception and multi-agent coordination
- Skills: Strong C/C++, RL
- Talk to David
- Paper to read:

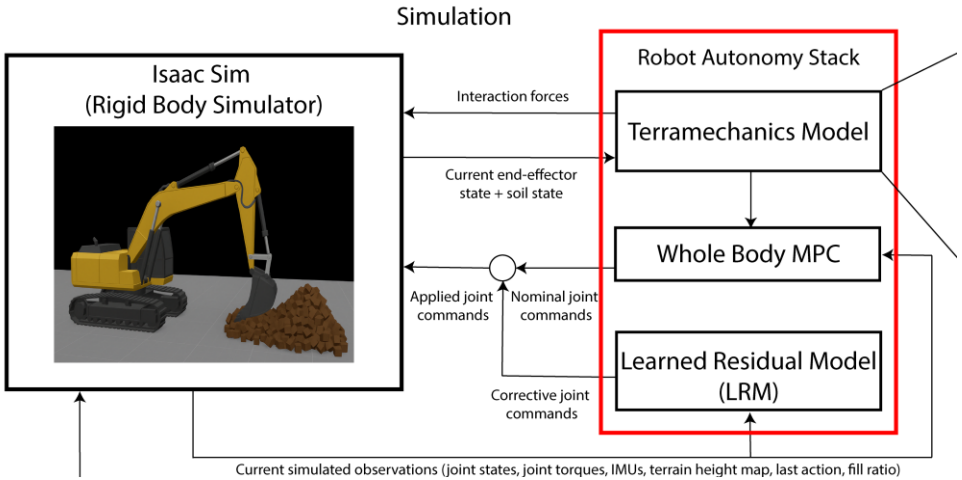
https://www.youtube.com/watch?v=kSXKjTxKpuA

Sean J. Wang; Honghao Zhu; and Aaron M. Johnson. “Pay Attention to How You Drive: Safe and Adaptive Model-Based Reinforcement Learning for Off-Road Driving.” In *IEEE Intl. Conference on Robotics and Automation*, 2024.
https://arxiv.org/pdf/2310.08674.pdf
https://youtu.be/5WgZQ_ALNHg

Project 2: Mud-interaction / Construction

- Simulation for contact modeling with mud/soil interaction
- Considering how legs, wheels, tracks, and scoops interact with soils
- Skills: C/C++
- Talk to Wensen or David
- Paper to read:

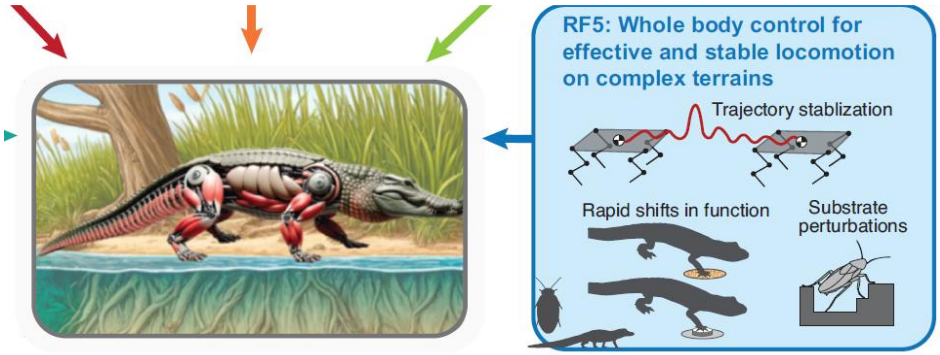


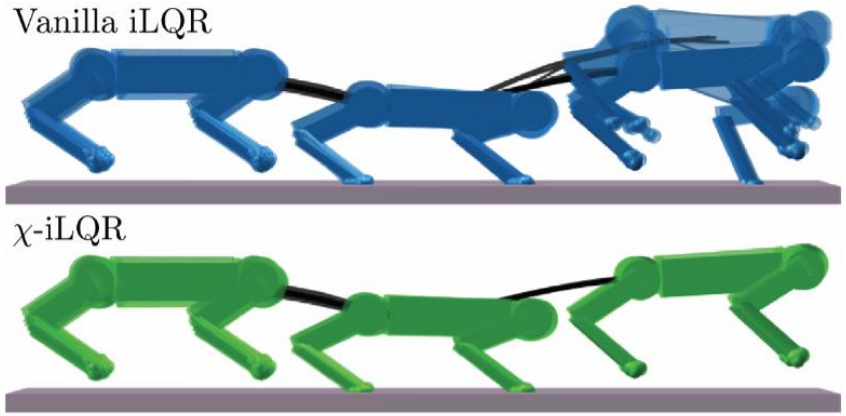


Catherine Pavlov; and Aaron M. Johnson. “A terramechanics model for high slip angle and skid with prediction of wheel-soil interaction geometry.” *Journal of Terramechanics*, 111: 9–19. 2024

Project 3: Muscle-Inspired Control

- Study muscles to understand the low-level reflex control and mechanics
- Create simulated model to look at muscle response. Compare stability loop of muscles to PID control
- Build a small robot arm using low-level muscle controller
- Skills: Strong classical and modern controls background
- Talk to Diana or Naomi
- Papers to read:





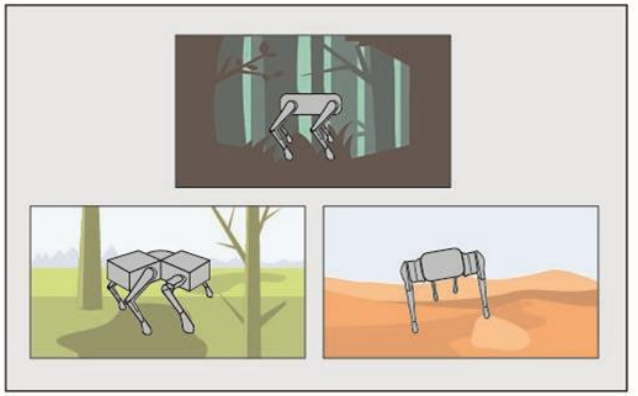
Yeo, S.-H., Verheul, J., Herzog, W. & Sueda, S. Numerical instability of Hill-type muscle models. *Journal of the Royal Society Interface* **20**, 20220430. ISSN: 1742-5689 (2023).

Zhu, J., Payne, J. J. & Johnson, A. M. Convergent iLQR for Safe Trajectory Planning and Control of Legged Robots in IEEE Intl. Conference on Robotics and Automation (2024),

Project 4: Paleo-Spined Design & Control

- Designing small paleo-inspired quadrupedal robots
- Create simulations to evaluate multiple designs
- Develop learned RL-based controller
- Skills: Python, Strong C/C++, simulation, Robot Design
- Talk to Aja
- Papers to read:

Extinct Animals (e.g., Dinosaurs)



New Robot Design

Lee, Joonho, et al., "Learning quadrupedal locomotion over challenging terrain." *Science Robotics* (2020)
Bishop, P.J, Pierce, S.E., "Late acquisition of erect hindlimb posture and function in the forerunners of therian mammals" *Science Advances* (2024)

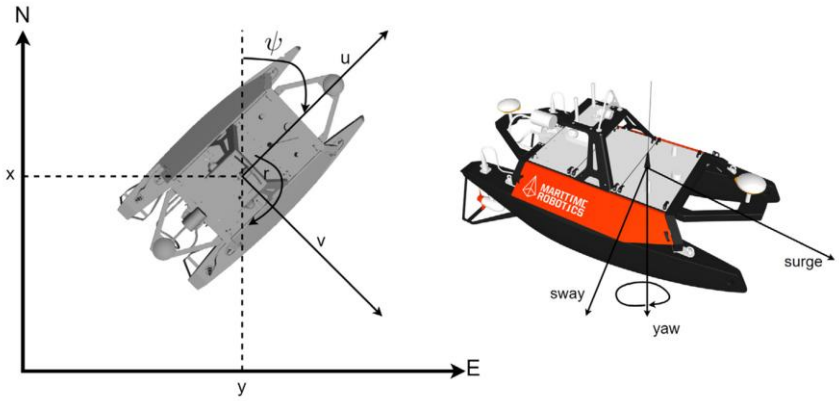
Project 5: Boat

- Dynamics discovery and optimal control of marine vessels
- Exploring how to control around disturbances such as waves and current
- Talk to Wensen
- Skills: Strong Python, optimal controls

Papers to read

[1] A. Hasan, "Physics-informed discovery of marine vessels dynamics from noisy data," *Ocean Engineering*, vol. 317, p. 120032, Feb. 2025, doi: 10.1016/j.oceaneng.2024.120032.

[2] R. Skjetne, T. I. Fossen, and P. V. Kokotović, "Adaptive maneuvering, with experiments, for a model ship in a marine control laboratory," Automatica, vol. 41, no. 2, pp. 289–298, Feb. 2005, doi: 10.1016/j.automatica.2004.10.006.



Coordinate system for USV dynamics modelling. Reproduced from [1]

Thank you!

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