The Robomechanics Lab

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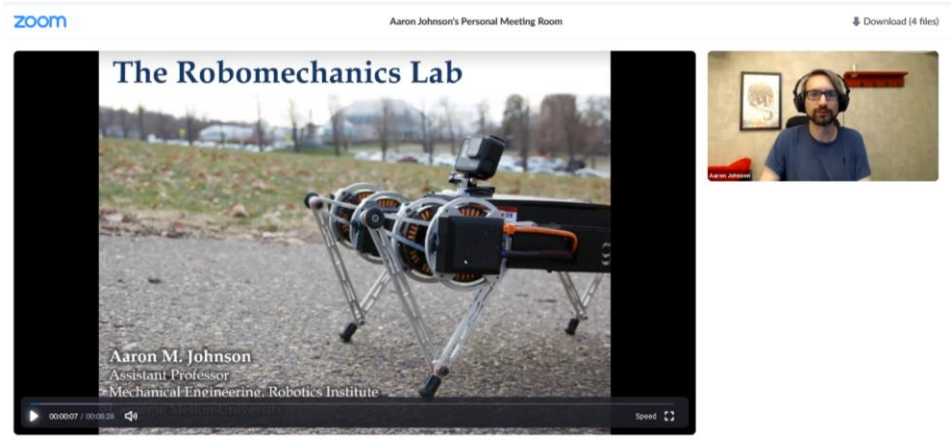
Lab Overview

Fall 2020 Overview Video:



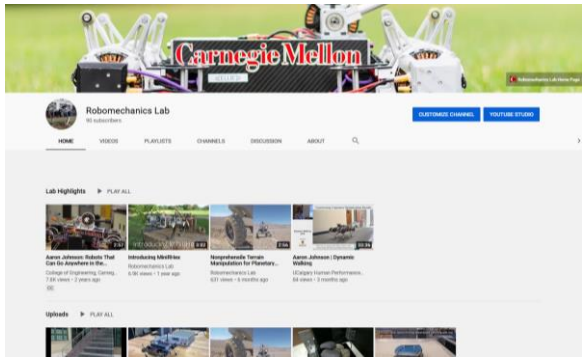
https://cmu.zoom.us/rec/share/us0rBKz28EpIRa_g-k7tR_MmIaW8eaa8hHMX-vEJmhs4mZrj8lktZ5VCMwo5_ZQ1

Spring 2021 Seminar:

https://www.youtube.com/watch?v=rtx5DV-TfKg

YouTube Channel with more talks and research videos:

https://www.youtube.com/channel/UCKD78aZAsdB9-JTwrt6Q1KA



Fall 2021 Projects

robomechanics.net
amj1@cmu.edu

- 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 me with:
     - Your resume
     - Why you want to work on that project (~2 sentences)
     - Availability the week before or after the start of the semester to setup a meeting
- Do you advise MS-C, MS-AS, or other non MS-R students?
  - Yes, but priority is for MS-R slots first.
- If I don't join your lab, can we still work together?
  - Yes! I teach Robot Dynamics & Analysis in the fall
- Do you fund MS-R students?
  - No. I wish I could!

Project 1: Perception on Rough Terrain

- Perception is hard for robots on rough terrain
- True for legged, wheeled, and tracked vehicles
- Can we incorporate better dynamics models to improve vision and SLAM?

- Skills: Some ROS and computer vision experience

- Likely MS student

- Paper to read:

Kumar, Payne, Travers, Johnson, and Choset. "Periodic SLAM: Using Cyclic Constraints to Improve the Performance of Visual-Inertial SLAM on Legged Robots." In *ICRA Workshop on Visual-Inertial Navigation Systems*, May 2021.
https://udel.edu/~ghuang/icra21-vins-workshop/papers/04-Kumar_PeriodicSLAM.pdf

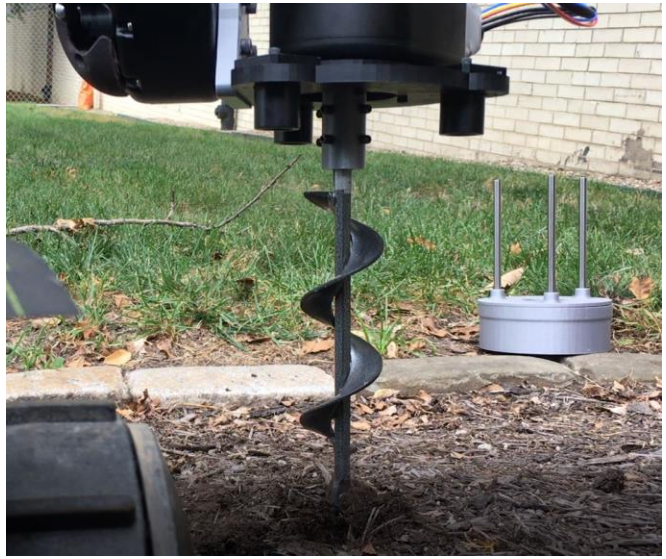
Project 2: Environmental Sampling

- Use robots to monitor for soil contamination
- So far, we have collected surface samples
- In this project we will explore sampling at deeper depths

- Skills: Mechanical design & analysis

- Likely undergrad

- Paper to read:



Blouin, Stéphane, Ahmad Hemami, and Mike Lipsett. "Review of resistive force models for earthmoving processes." *Journal of Aerospace Engineering* 14, no. 3 (2001): 102-111. https://ascelibrary.org/doi/pdf/10.1061/(ASCE)0893-1321(2001)14%3A3(102)

Project 3: Why Legs?

- Many animals use legs to travers challenging terrain
- On the other hand, the wheel is often considered our best invention ever, and can do a lot
- When do we really need legs?
- In particular, moving around vegetation

- Skills: Kinematics analysis, behavior programming in ROS

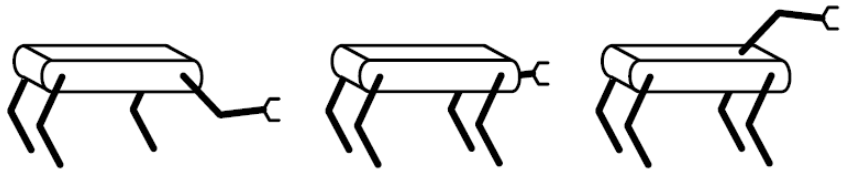
- Undergrad or MS

- Paper to read:

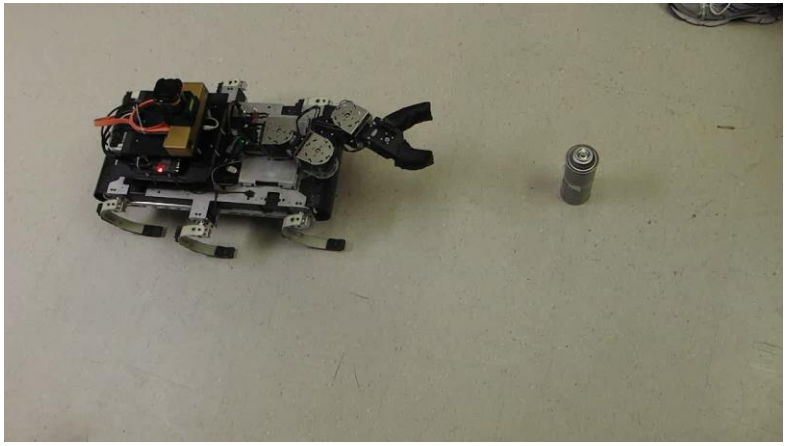
Full, Robert J., and Daniel E. Koditschek. "Templates and anchors: neuromechanical hypotheses of legged locomotion on land." *Journal of experimental biology* 202.23 (1999): 3325-3332. https://kodlab.seas.upenn.edu/uploads/Kod/Full99a.pdf

Project 4: A Robot Dog "Mouth"

- Dogs use their mouth as a dexterous manipulator
- Most robot quadrupeds that have a manipulator add a fifth appendage
- What are the tradeoffs if we instead attach it to the body?



- Skills: Mechanical design & analysis



- Likely undergrad

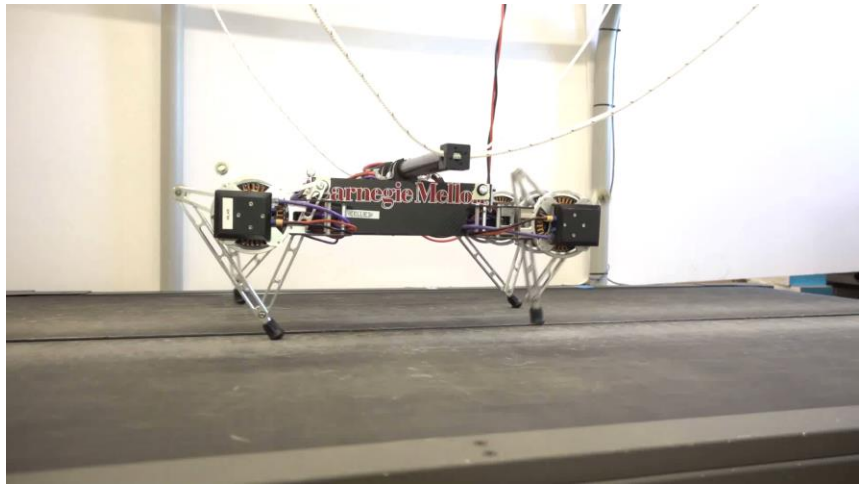
- Paper to read:

Norby, Li, Selby, Patel, and Johnson. "Enabling dynamic behaviors with aerodynamic drag in lightweight tails." *IEEE Transactions on Robotics*. 2021.
(Similar project type on bio-inspired design, different topic)

http://www.andrew.cmu.edu/user/amj1/papers/TRO2021_Aerodynamic_Tails.pdf

Project 5: Learning How To Walk

- How can we learn new behaviors that work reliably?
- Challenge is that simulation data is cheap but wrong, and robot data is expensive but correct



- Skills: Machine learning
- Likely MS
- Paper to read:

Kumar, A., Fu, Z., Pathak, D., & Malik, J. RMA: Rapid motor adaptation for legged robots. *Robotics: Science and Systems.* 2021
https://ashish-kmr.github.io/rma-legged-robots/

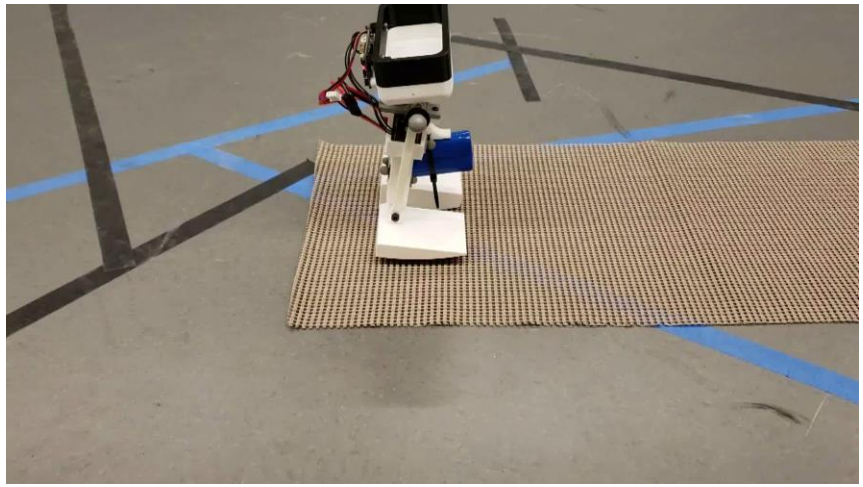
Project 6: Simple Walking Machines

- What is the simplest walking machine?
- How does walking scale to larger and smaller sizes?
- How does design and control trade off?

- Skills: Mechanical design and analysis

- Likely undergrad

- Paper to read:



Tedrake, Russ, Teresa Weirui Zhang, Ming-fai Fong, and H. Sebastian Seung. "Actuating a simple 3D passive dynamic walker." In *IEEE International Conference on Robotics and Automation,* 2004. https://groups.csail.mit.edu/robotics-center/public_papers/Tedrake04.pdf

Thank you!

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