High-level perception and control for autonomous reconfigurable modular robots

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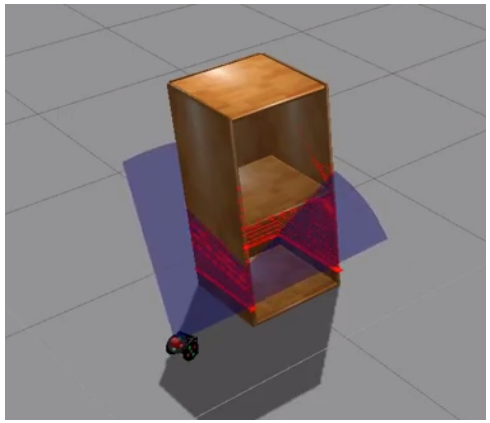
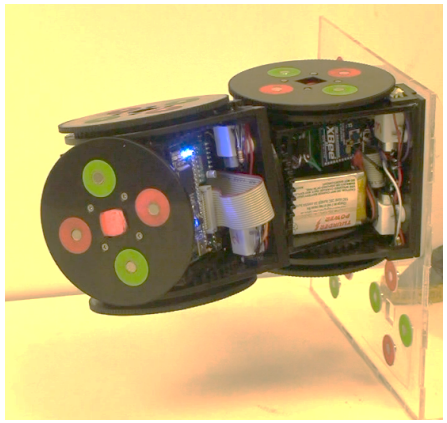
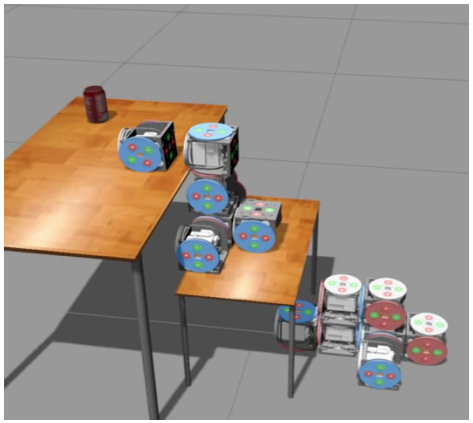
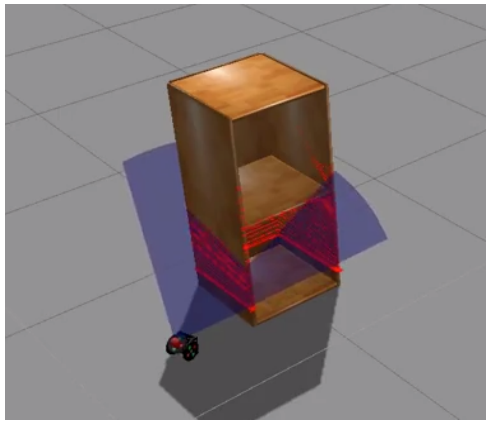
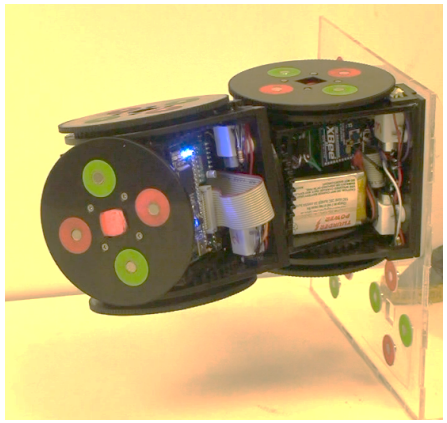
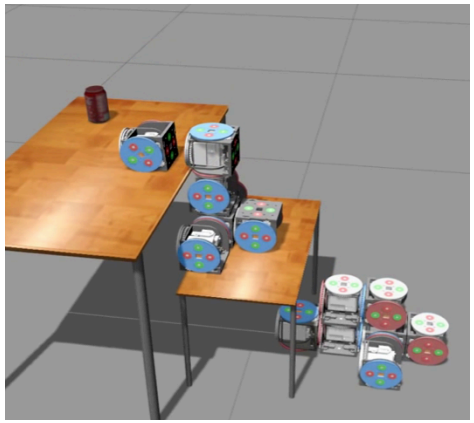
Students: Yunkai Cui, Jonathan Daudelin, Jay Davey, Gangyuan Jing, Daniel Lee, Tarik Tosun

Goal

Develop the theory, hardware and computational infrastructure to enable **automatically transforming user-defined, high-level tasks into correct, perception informed control and configurations for modular robots**

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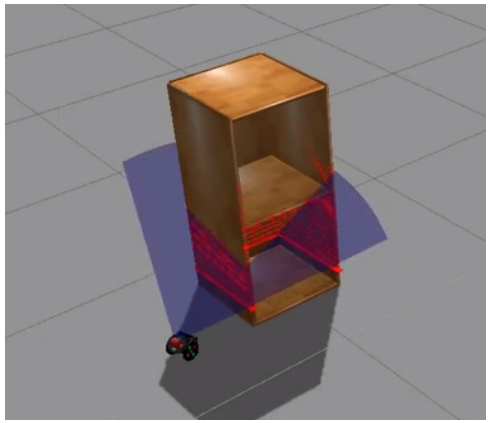
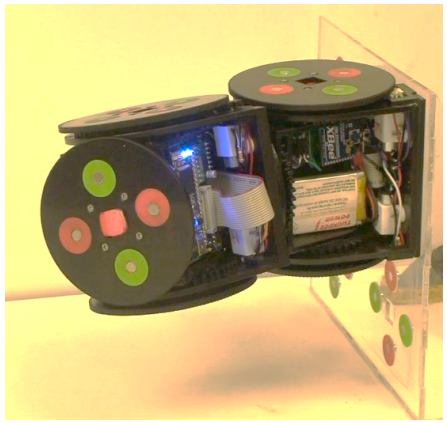
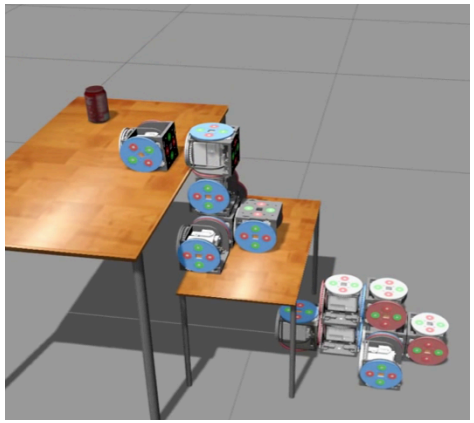

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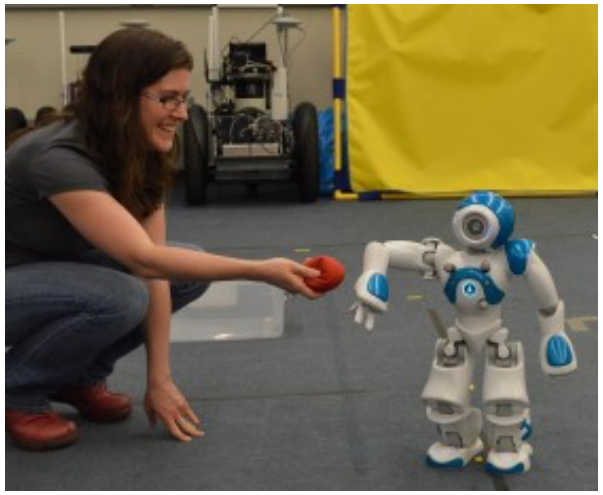

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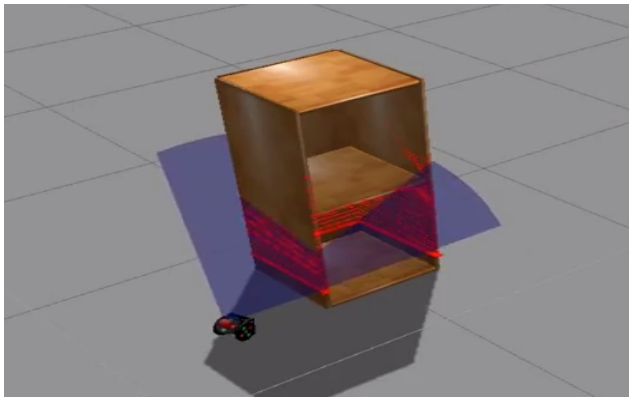

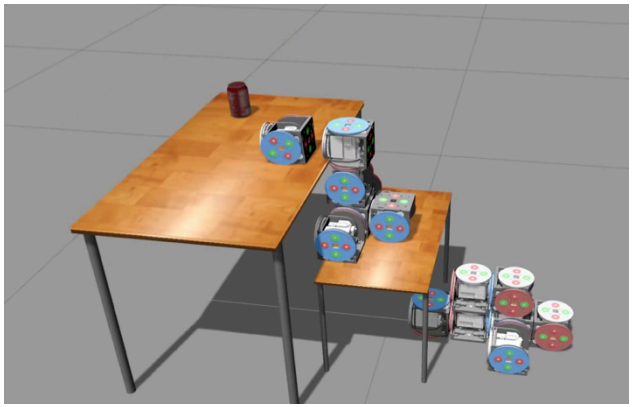

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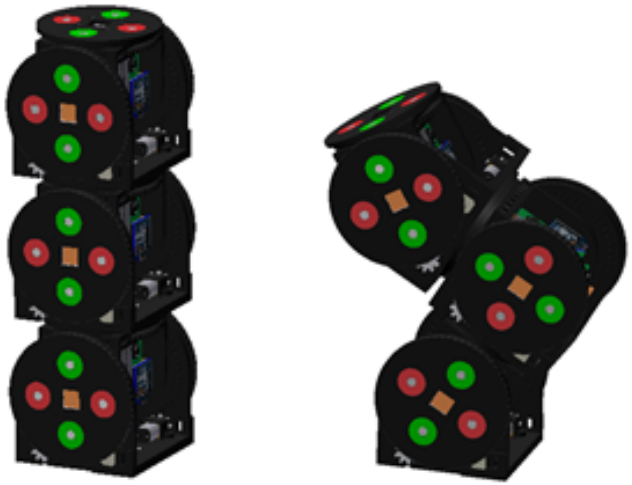


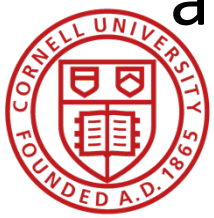
More Specifically…

- Given a set of modules:

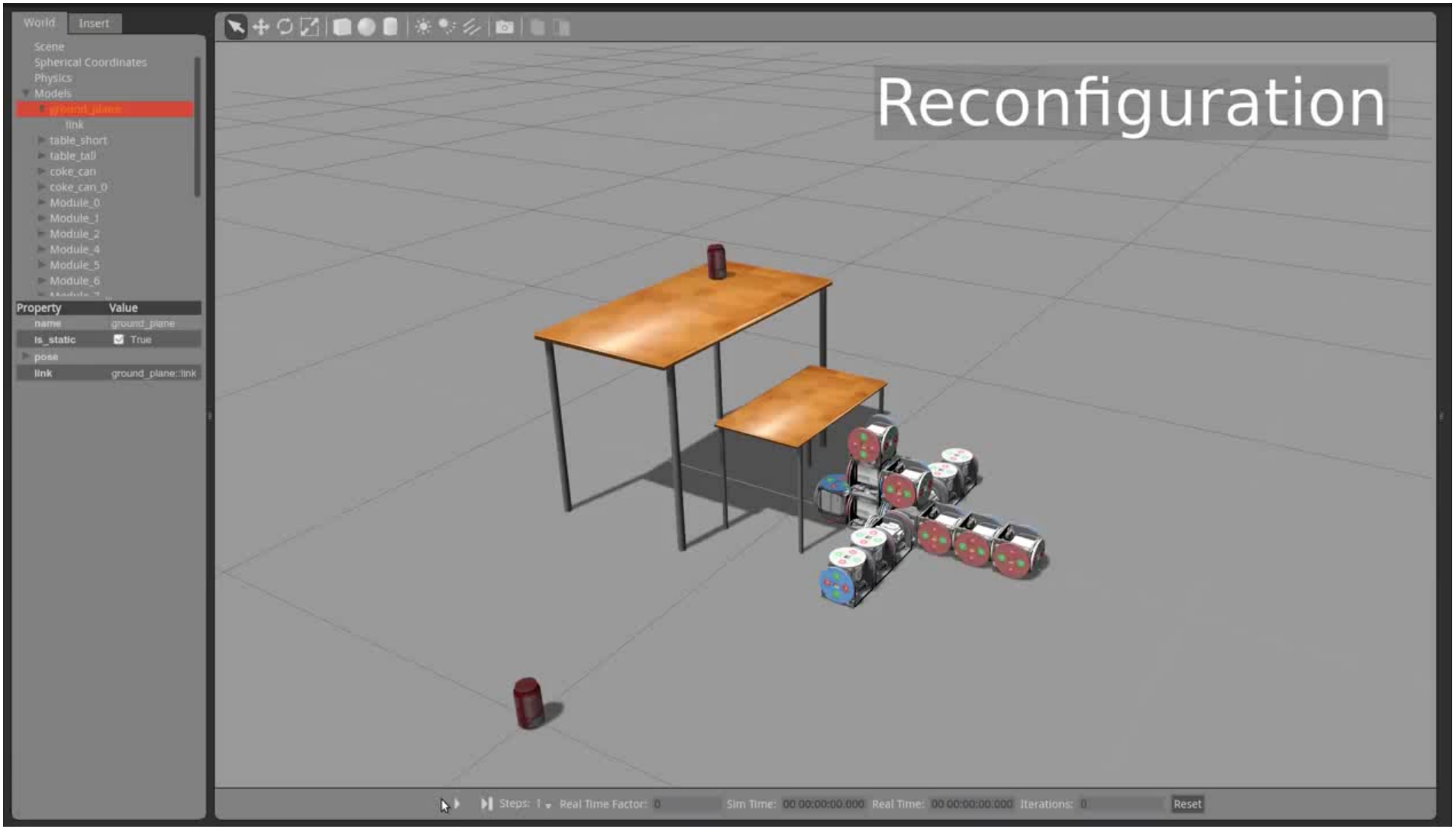
- And a high-level task:

" Bring me the can that is on the table"

- Automatically synthesize: locomotion, perception and reconfiguration commands to achieve the task



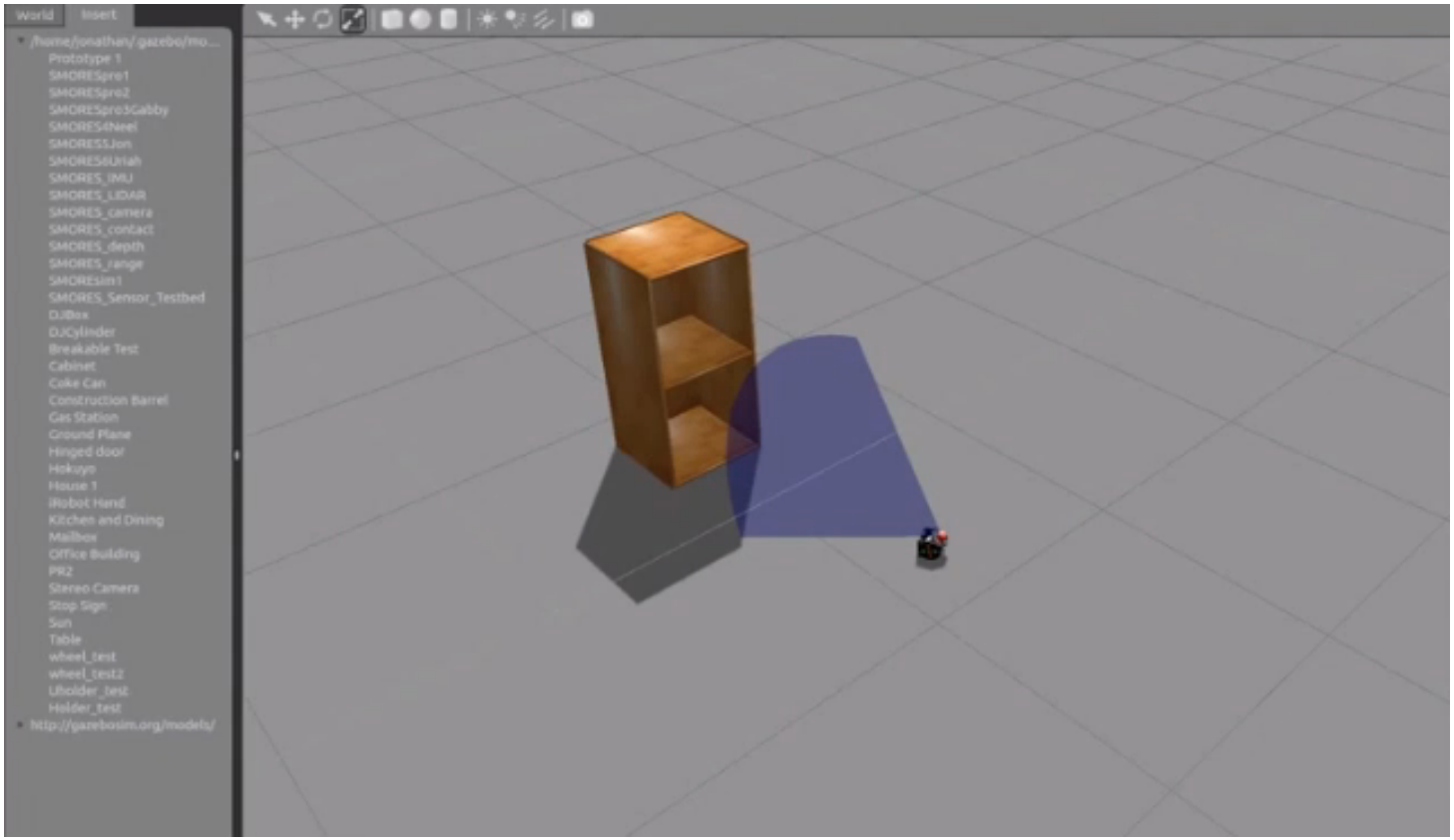
Simulation Results (Year 1)



Novelty/Challenges

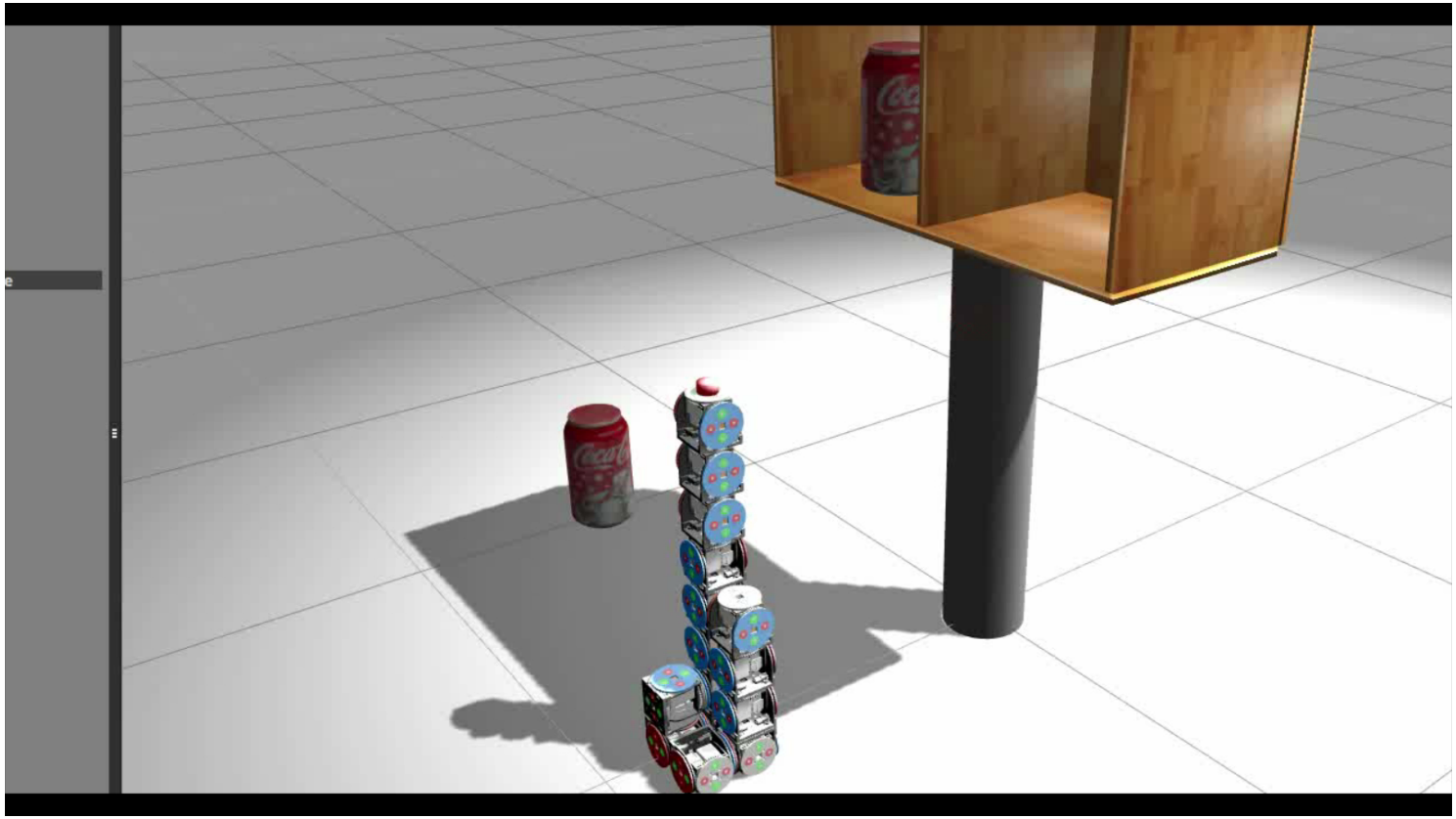
- Correct-by-construction control synthesis
  - Both control and configuration (and number)
  - Tasks include Locomotion, Active Sensing / Information Gathering, Grasping, etc.
- Library of controllers/configurations
  - "Crowd sourced" (education/outreach)
  - Composed in a probabilistic verified way
    - e.g. 4 legs and a body: no collisions, stability, etc.
- Novel self reconfigurable hardware

Active Information Gathering



- Single-line laser+camera sensor

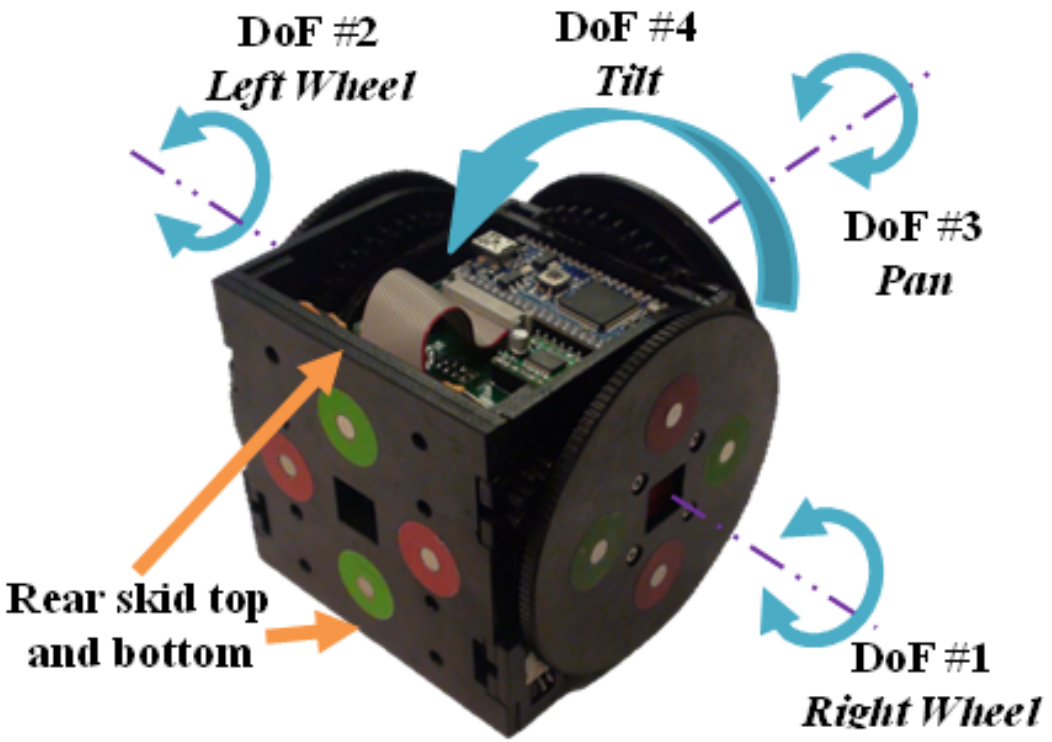
Active Information Gathering



- Single-line laser+camera sensor
- Configuration and locomotion for active sensing

Hardware

- 4 DOF
- Electro-magnets allow autonomous connection/ disconnection
- Specialized modules:
  - Sensor
  - Brain
  - Passive



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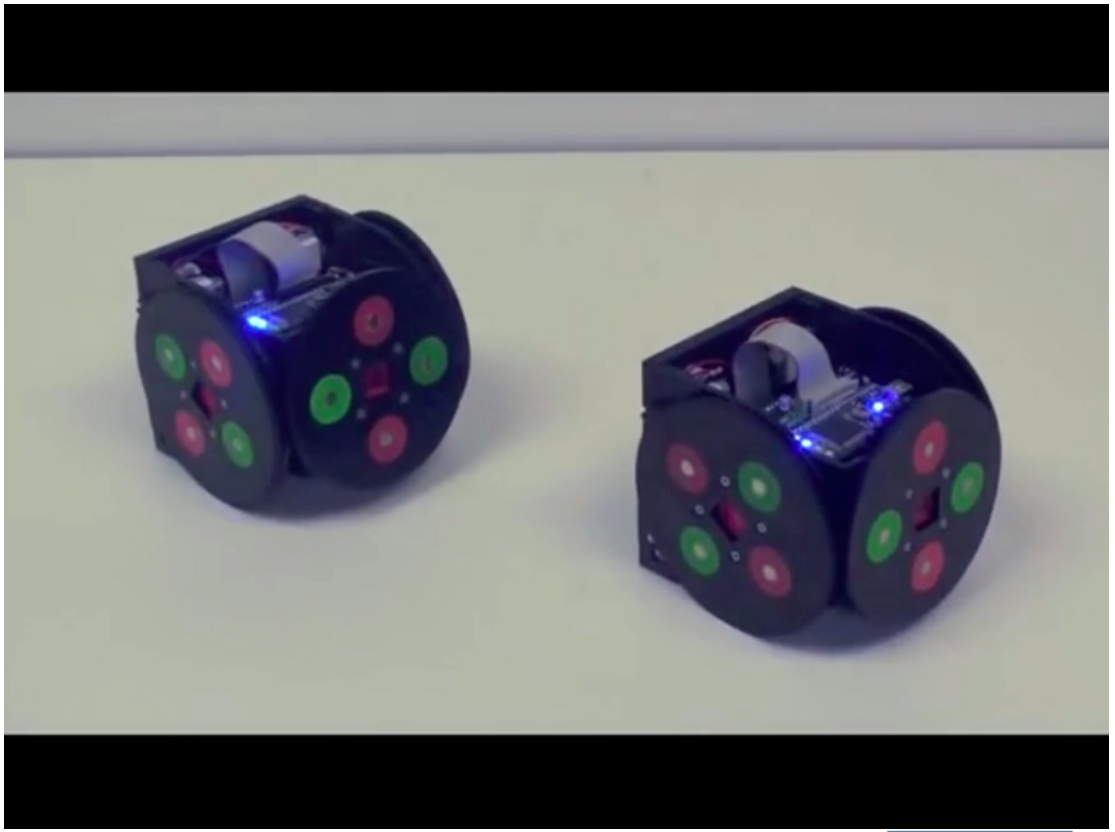
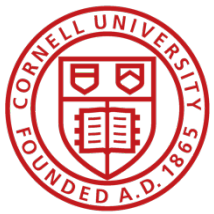
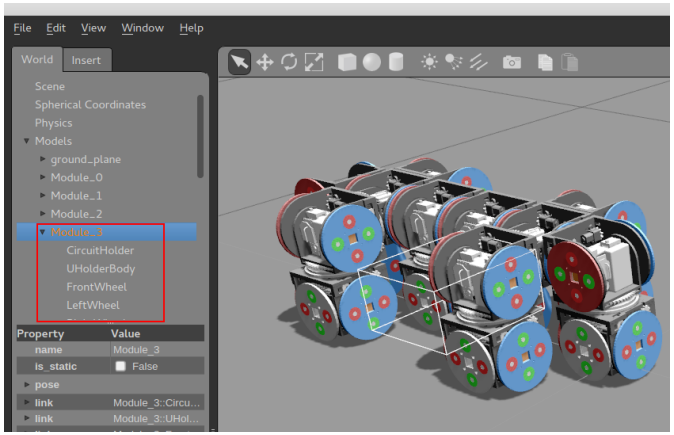
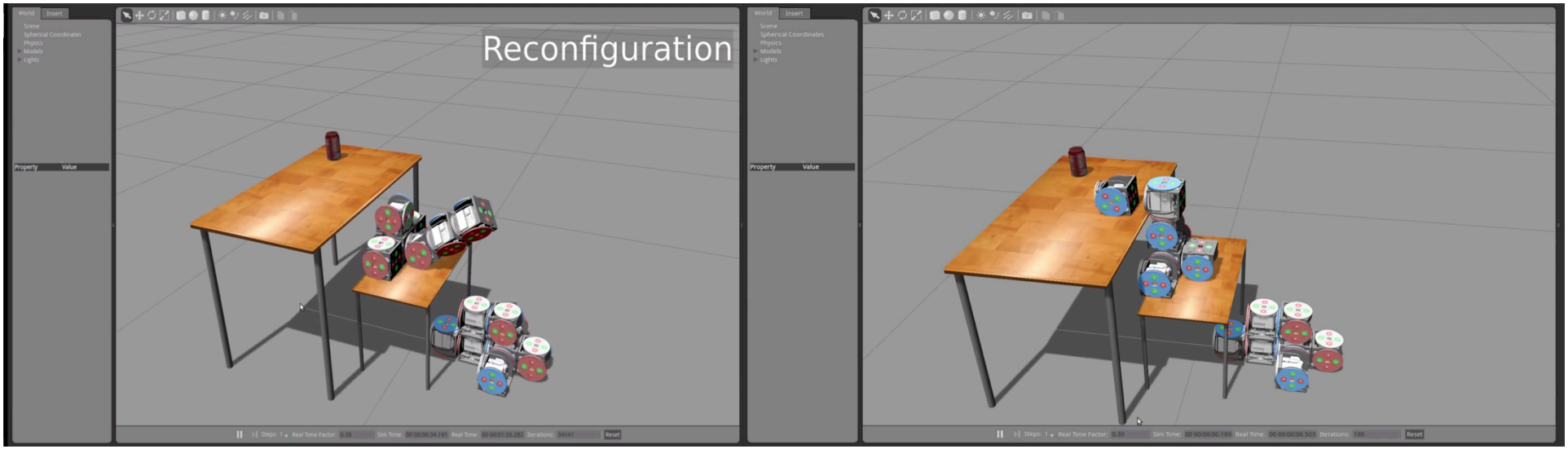




Crowd-Sourcing Controllers/Configurations

- Using GAZEBO: tools for creating a library of configurations/controllers:
  - Configuration Editor
  - Gait Recorder
  - Simulation Controller





Future Plans

- Year 2
  - Crowd-sourcing
  - Library development
  - Synthesize and verification
  - Brain, sensor, structure and motion modules
- Year 3
  - Full hardware
  - Integration of perception with synthesis
  - Probabilistic verification
  - Complex tasks, leading to final demo

Final Demo: Two very different applications, same modules, within an hour:

Car inspection and personal robot delivery