

Current directions for DRC Ladder Climbing

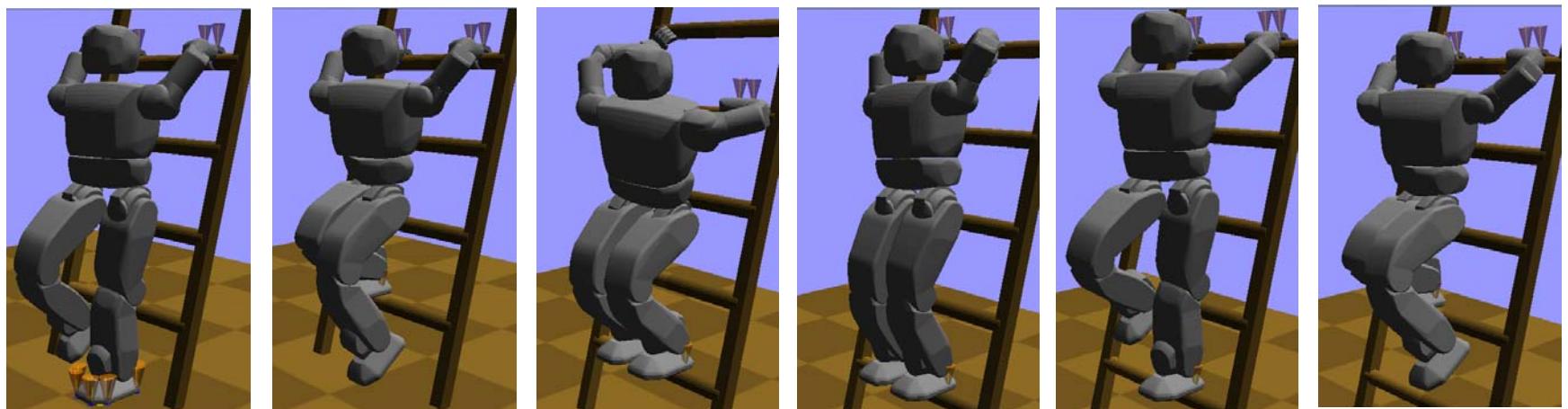


Kris Hauser
Indiana University
2/15/2013

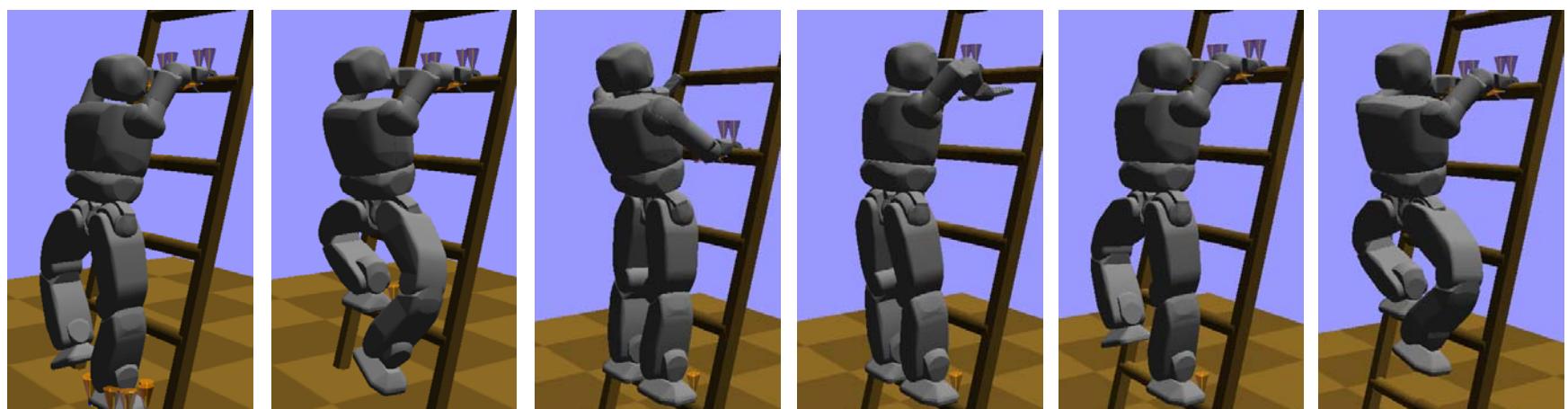


Two successful strategies on 30cm rung-spacing

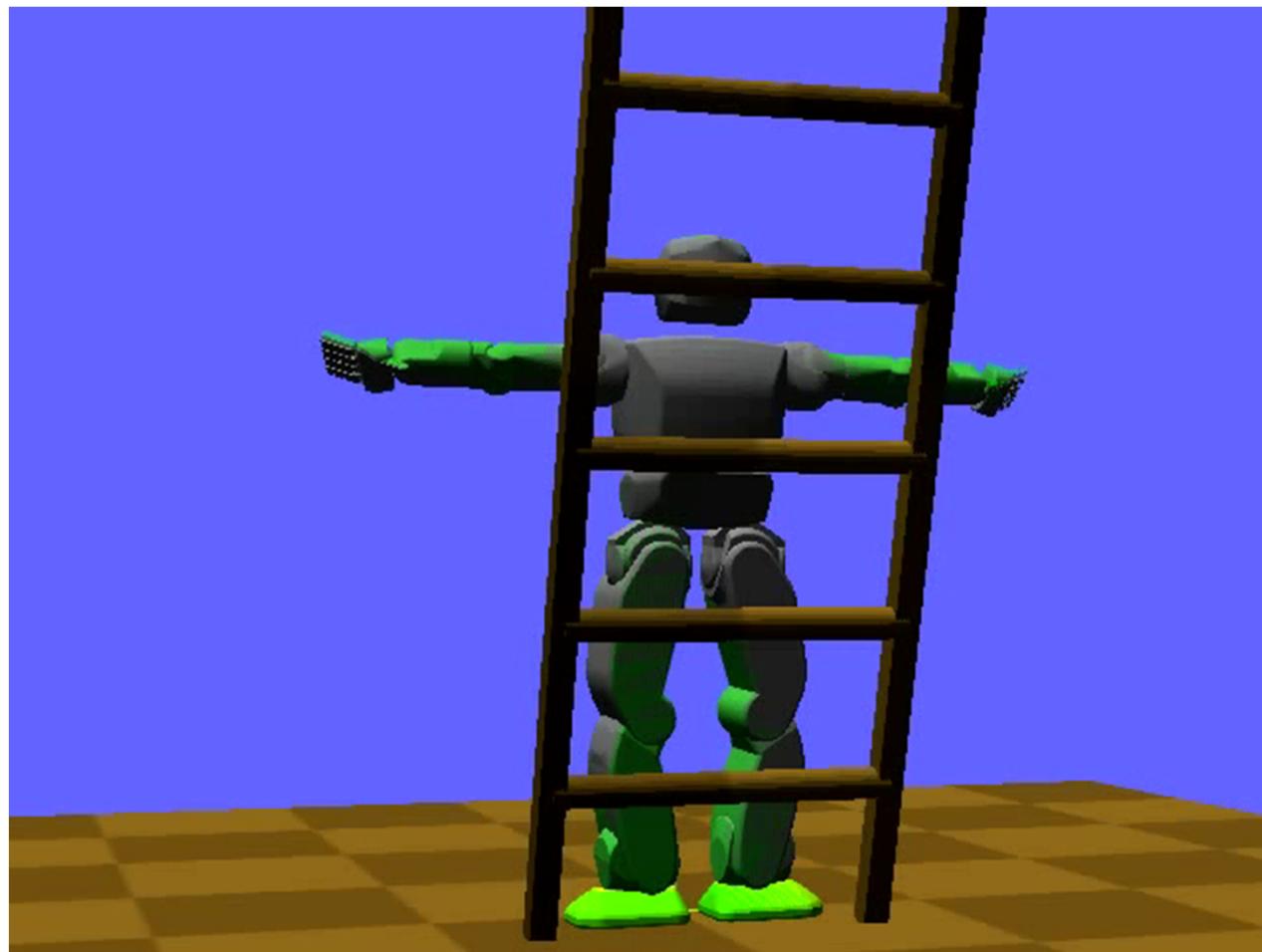
Backward



Splayed-feet, close hands



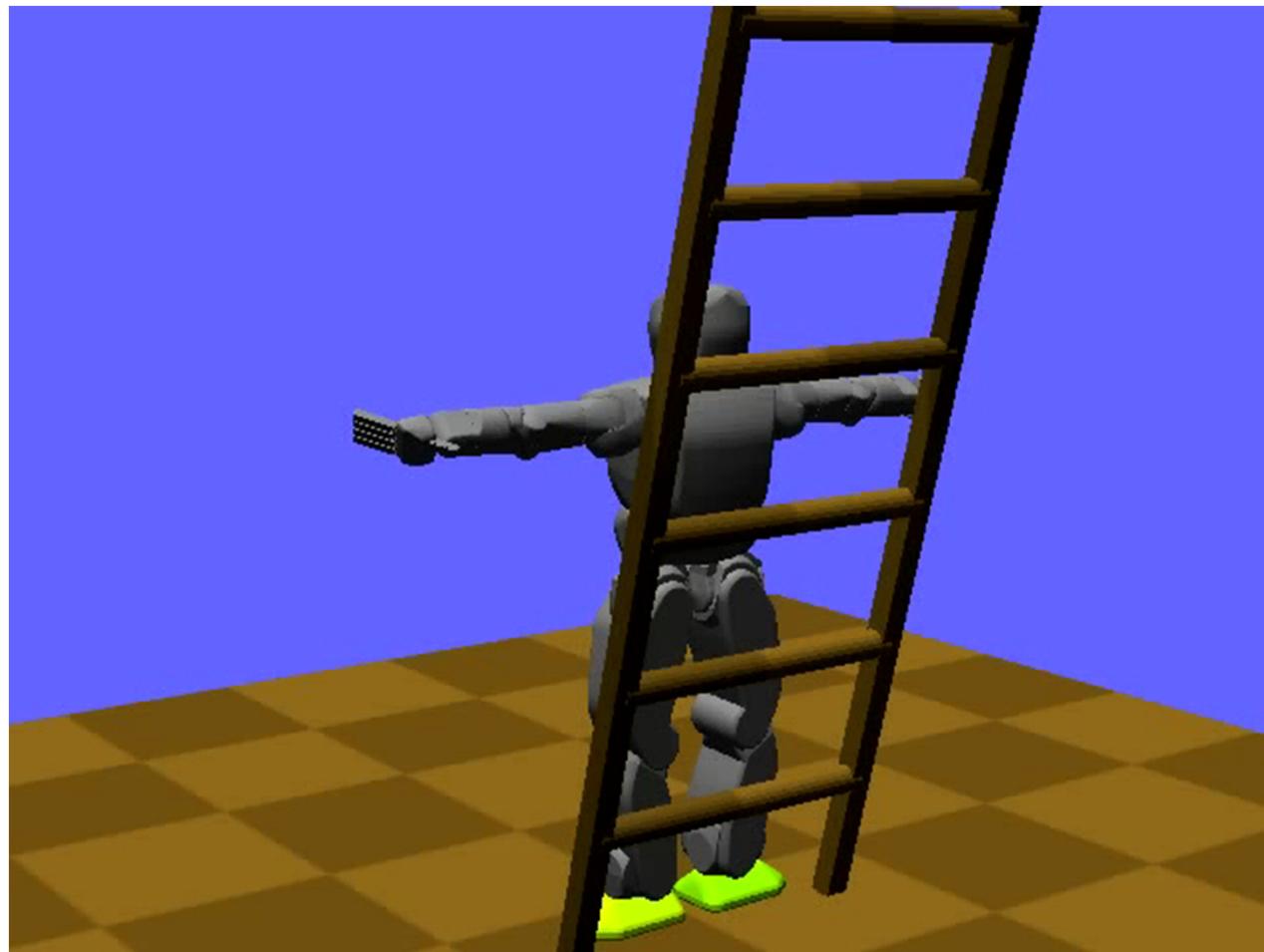
High max grip force (2Nm/finger joint)



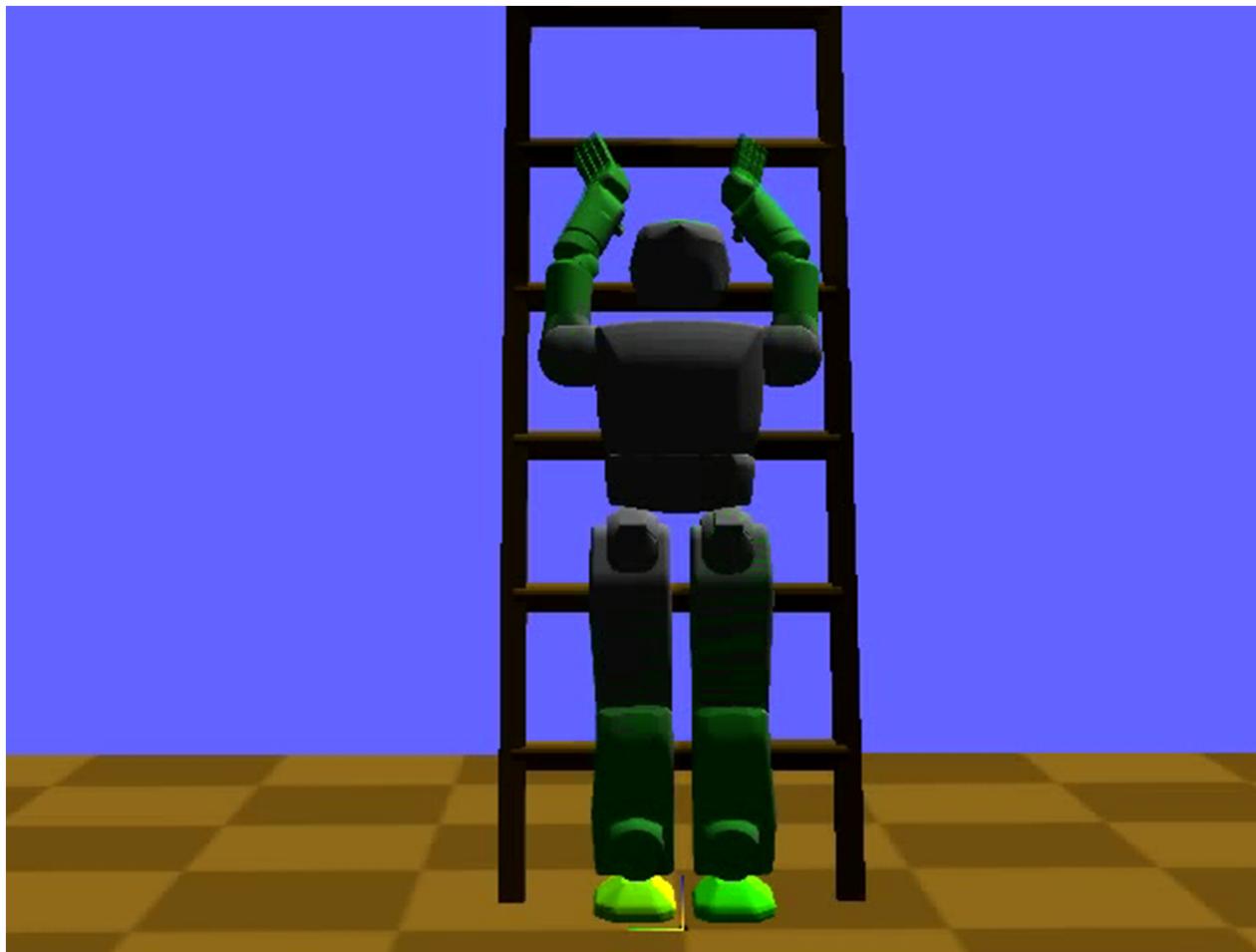
Overview

- **Planning for mounting and climbing is nearly solved!**
 - Dismount remains
 - Vertical / A-frame ladders need testing
- Improving efficiency of motions
 - Grip force, time, dynamics optimization
- Integration with sensing and control
- CDR Goal: Demo on Purdue lab setup

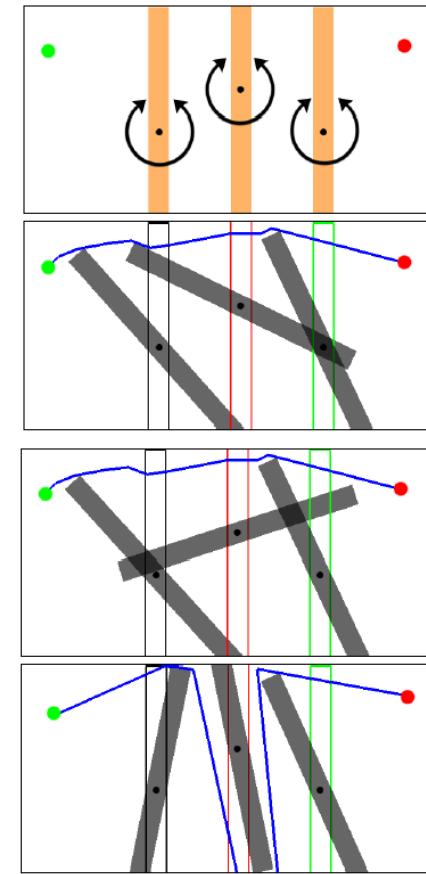
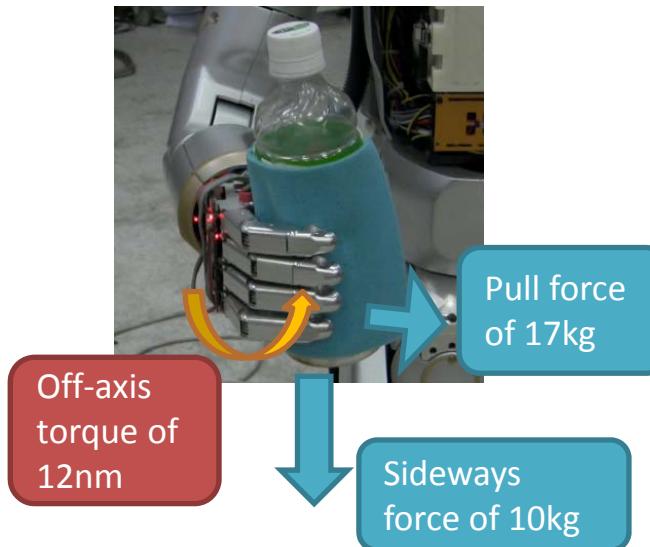
Lower grip force (1 Nm/finger)



Backward climb: PD control fails

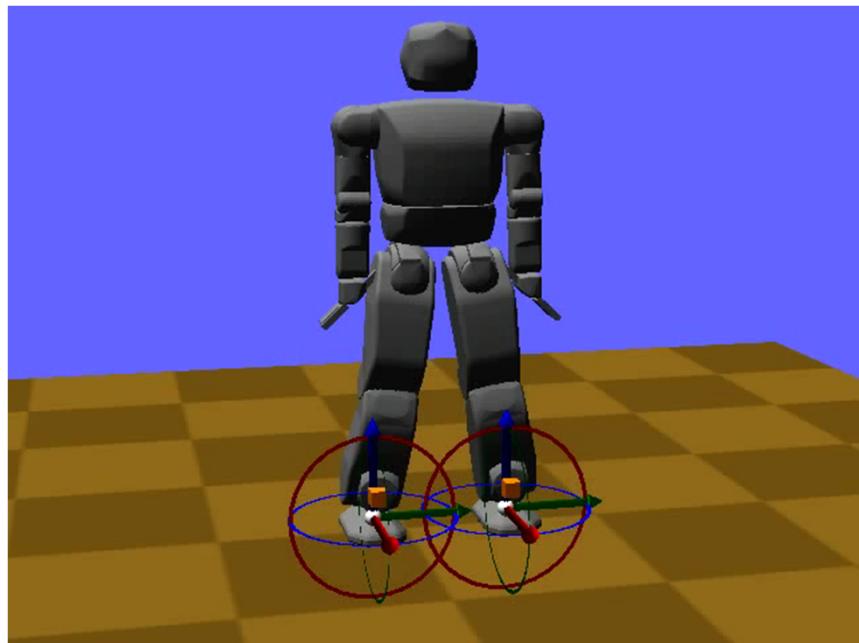


Grip force optimization

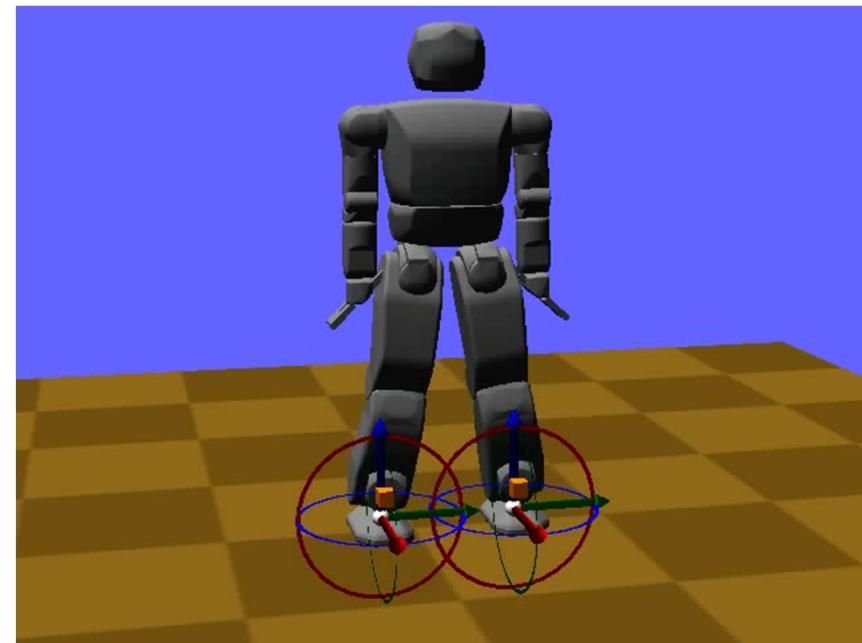


- Minimum Constraint Displacement motion planner
- Reduce max force from 7.2 kg to 2.5kg for FW climb, from 3.2kg to 2.4kg for BW climb

New time-optimization algorithm for multiple contact constraints



Linear interpolation induces
sharp changes in velocity



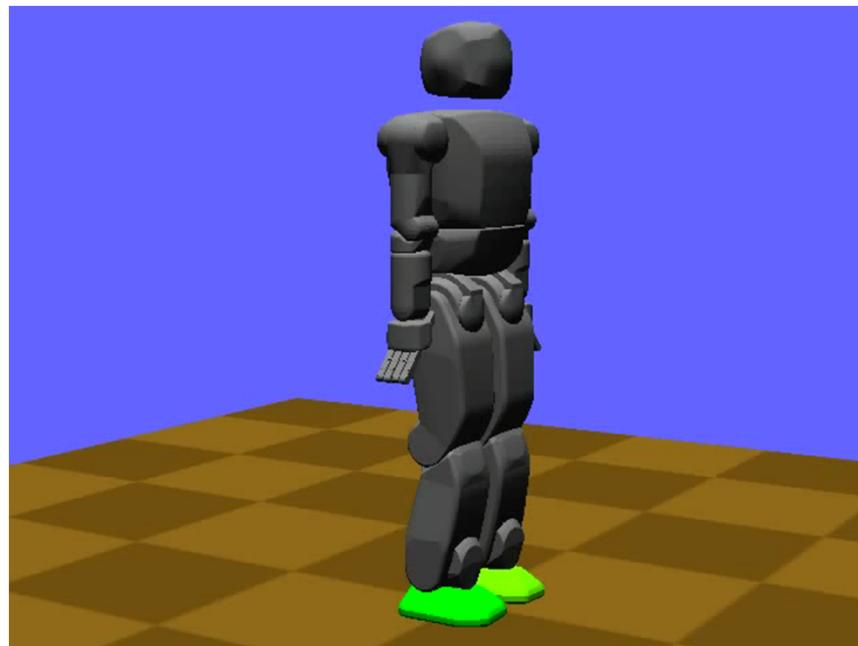
Time-optimal interpolation
respects accel/velocity bounds

Running times $\sim 0.5\text{s}$ for each step
 $\sim 7\text{-}8\text{s}$ for 16-step ladder climb

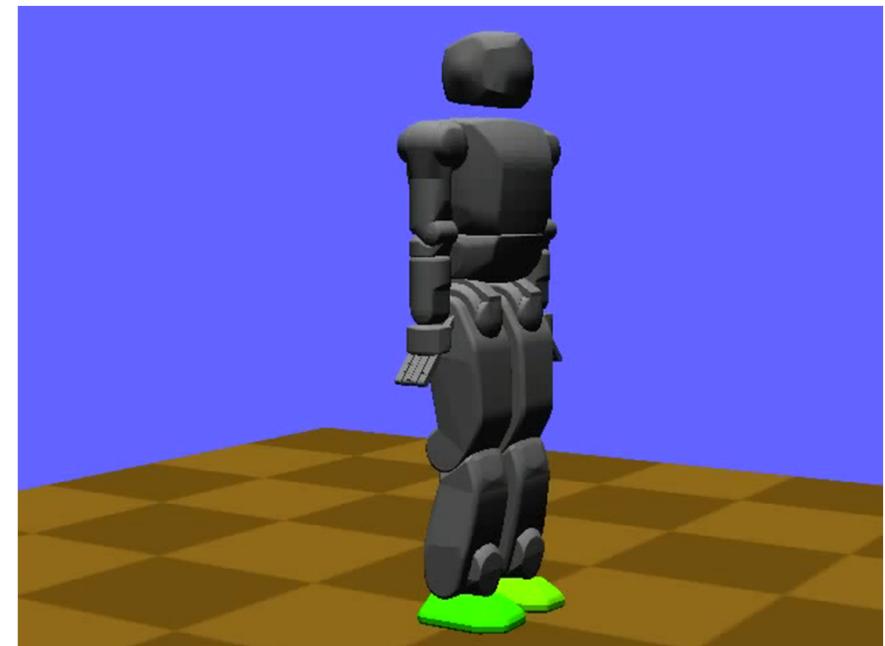
Open Dynamics Engine simulations

Linear paths $p(u):[0,1] \rightarrow \mathbb{R}^n$

- Time parameterization is unknown
- Discontinuity at start/goal/intermediate milestones add oscillations during execution



Linear interpolation

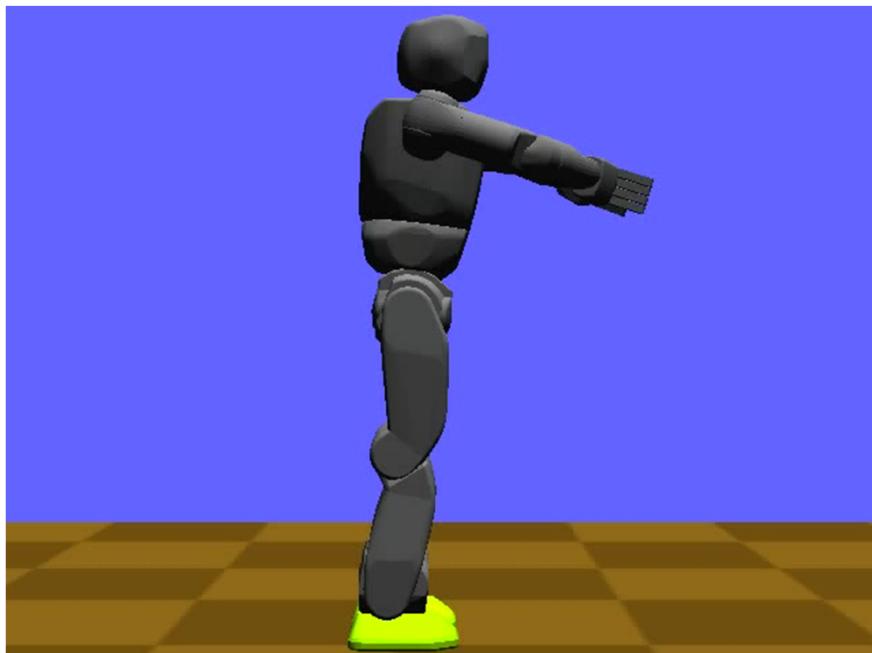


Time-optimal interpolation

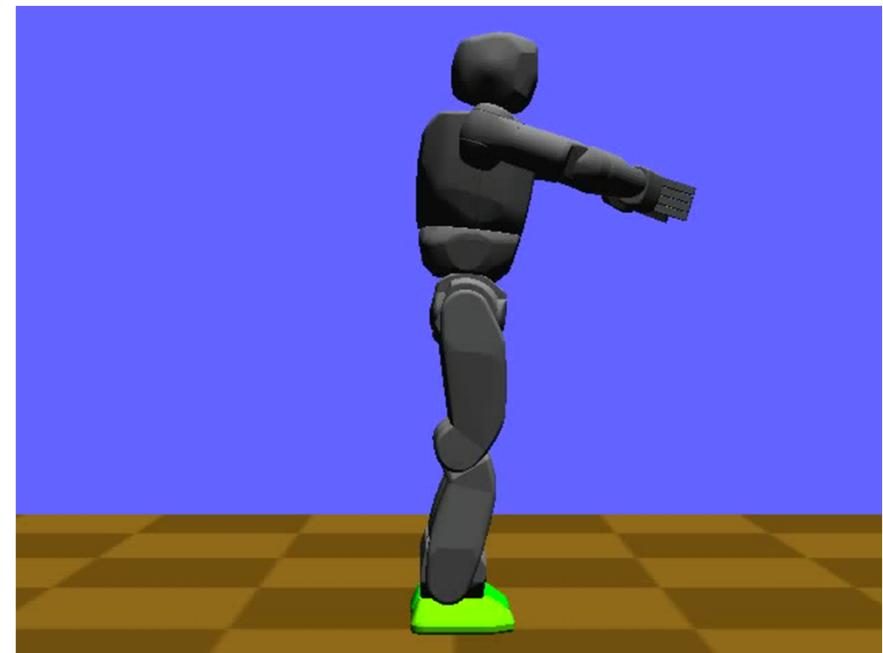
Open Dynamics Engine simulations

Linear paths $p(u):[0,1] \rightarrow \mathbb{R}^n$

- Time parameterization is unknown
- Discontinuity at start/goal/intermediate milestones add oscillations during execution



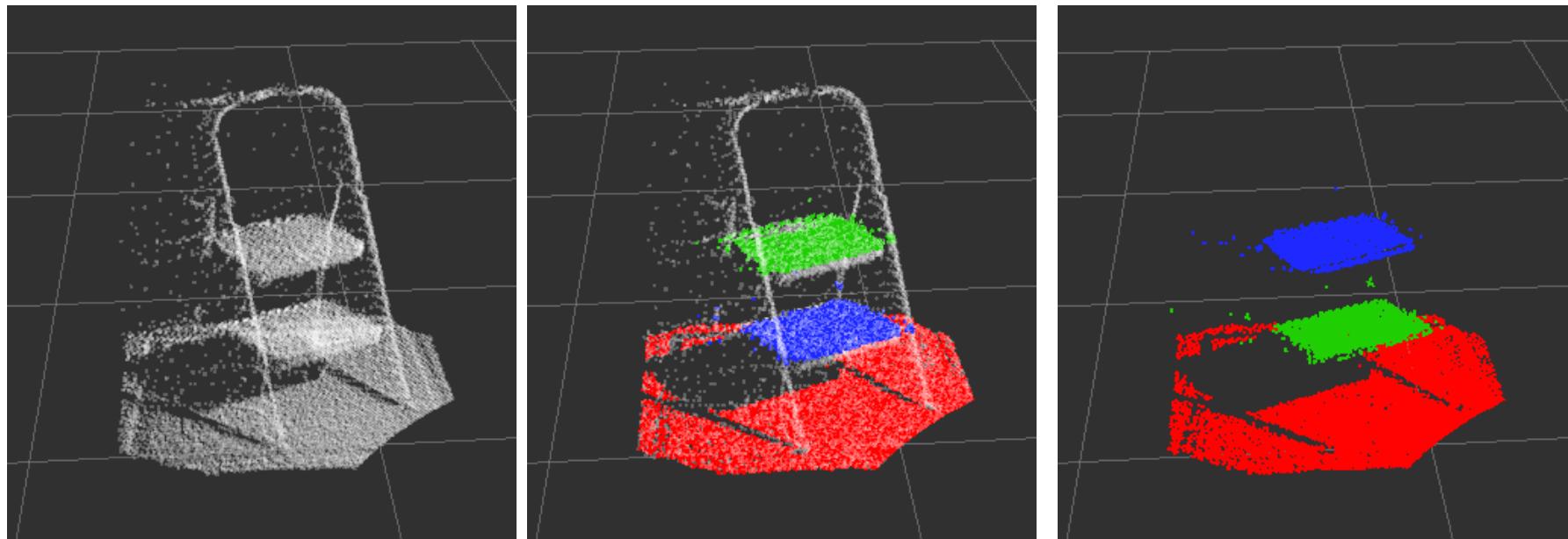
Linear interpolation



Time-optimal interpolation

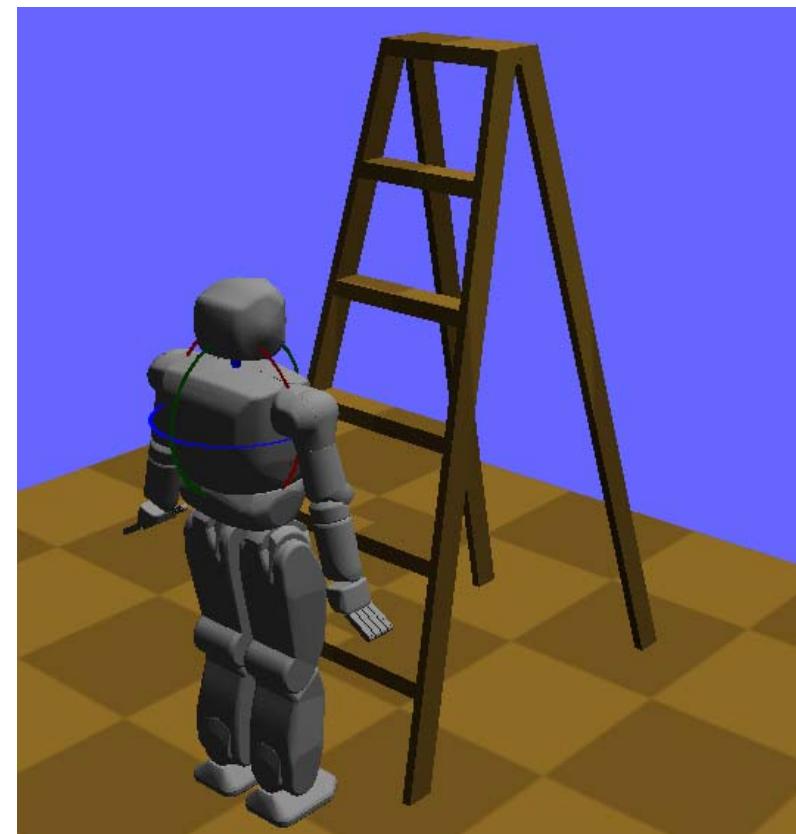
Sensing Approach

- Model-based approaches are sensitive to ladder database, not generalizable to e.g., stairs, vehicle ingress/egress
- Semantic labeling of scene patches (ongoing)
 - E.g., flat ground, rung, handrail, learned from basic geometric primitives (planes, cylinders, spheres)
- Future work
 - Classifying macro-objects from patches (e.g., “ladder”, “stairway”)



Goals for CDR

- Climb the A-frame ladder at Purdue
- Demonstrate vertical ladder climbing in sim
- Would be great to have new hands, but in the meantime...
 - Hooks?



Thanks!