MPC-feedback Trajectory Optimization for Wheeled Robot

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Semester Thesis, Final Presentation

Robotic Systems Lab, ETH Zurich

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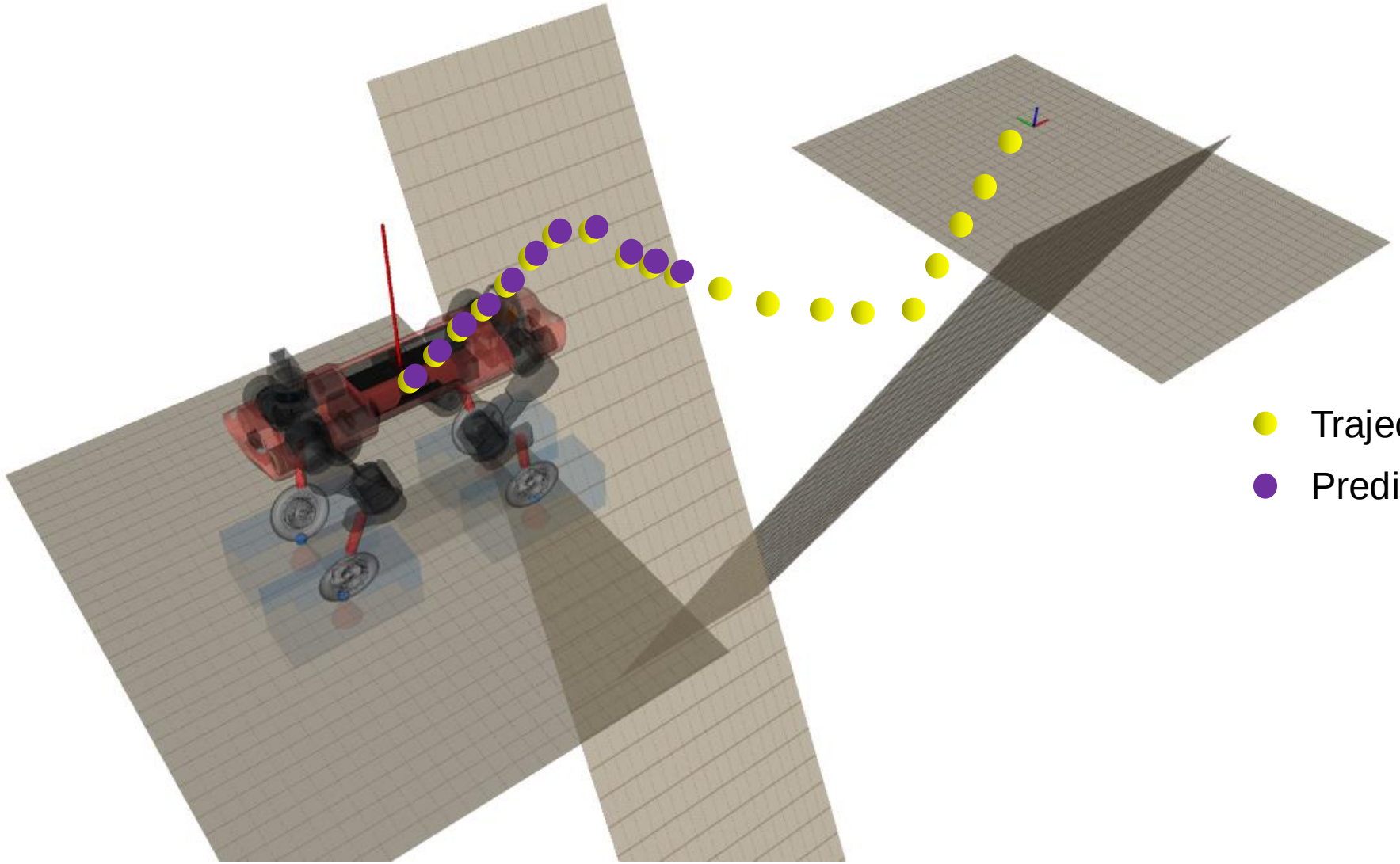
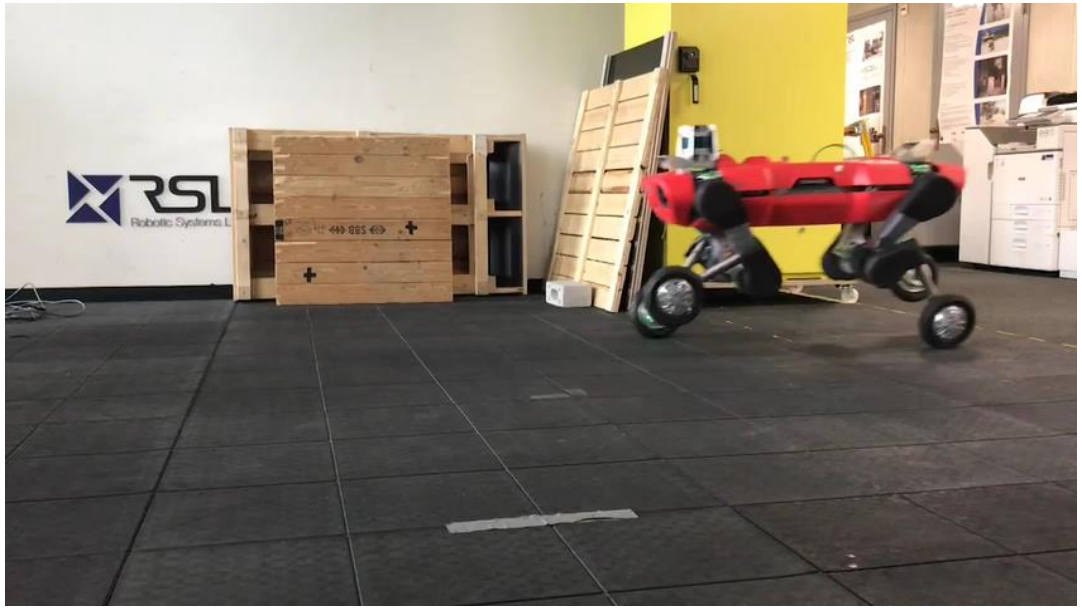
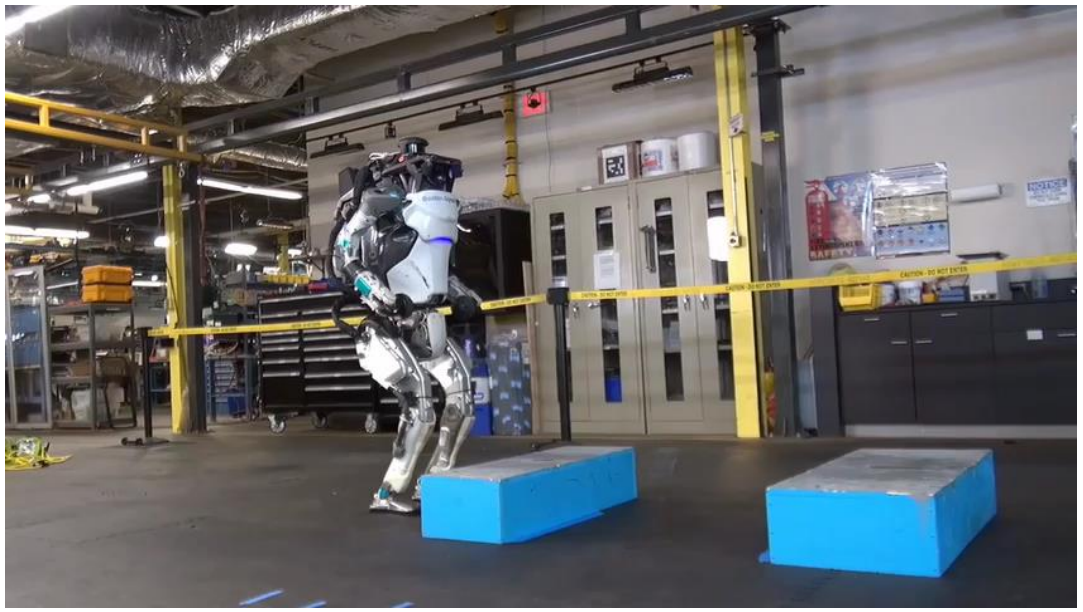
Motivation



Motivation



Anymal Wheels: Hybrid and versatile motions/gaits.



Boston Dynamics: Atlas

Video sources:
1. https://www.youtube.com/watch?v=_rPvKIvyw2w&feature=emb_logo
2. https://www.youtube.com/watch?v=fRj34o4hN4I&feature=youtu.be

MPC-feedback Controller

Reference trajectory $q, \dot{q}$

Inverse kinematics

Wheel, base position, etc.

towr
Trajectory Optimizer for Walking Robots

Trajectory optimizer

Smart initialization

Target

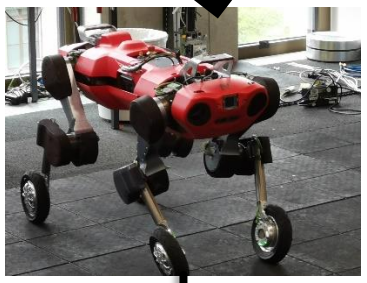
Offline

Model predictive control: 20 Hz

Desired control plan

Low level controller: 400 Hz

Torque commands



Robot states

Online

MPC Optimization Illustration

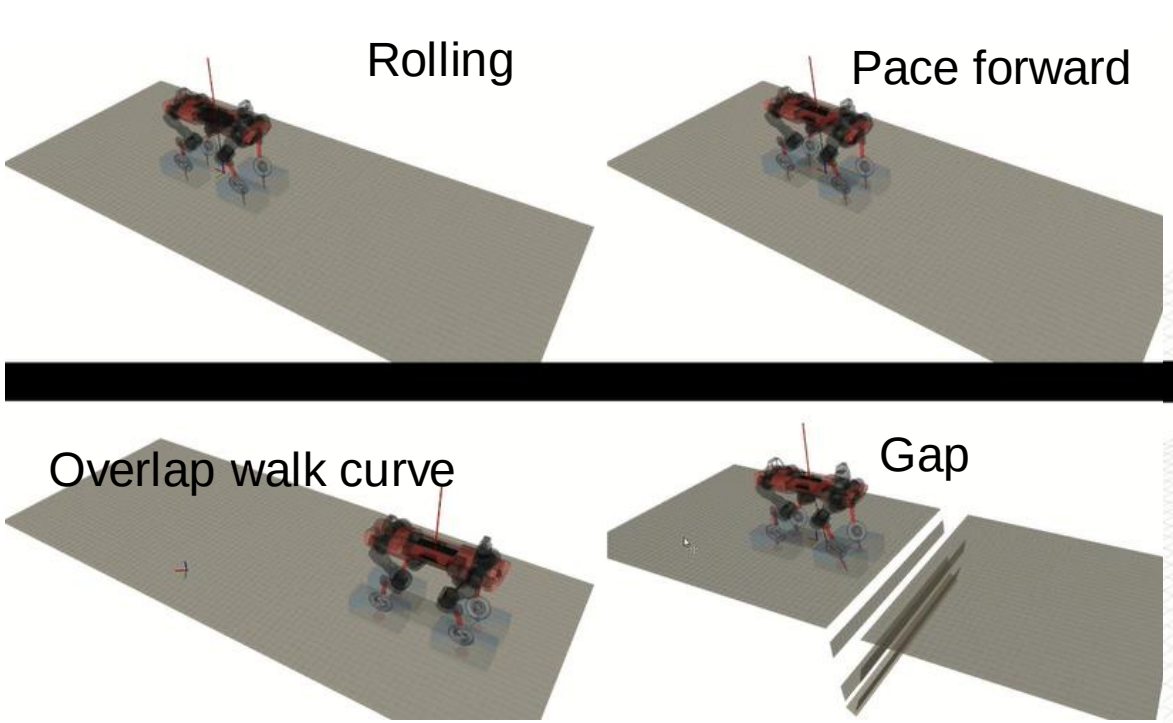


Fig.1 Desired trajectory generated by towr.

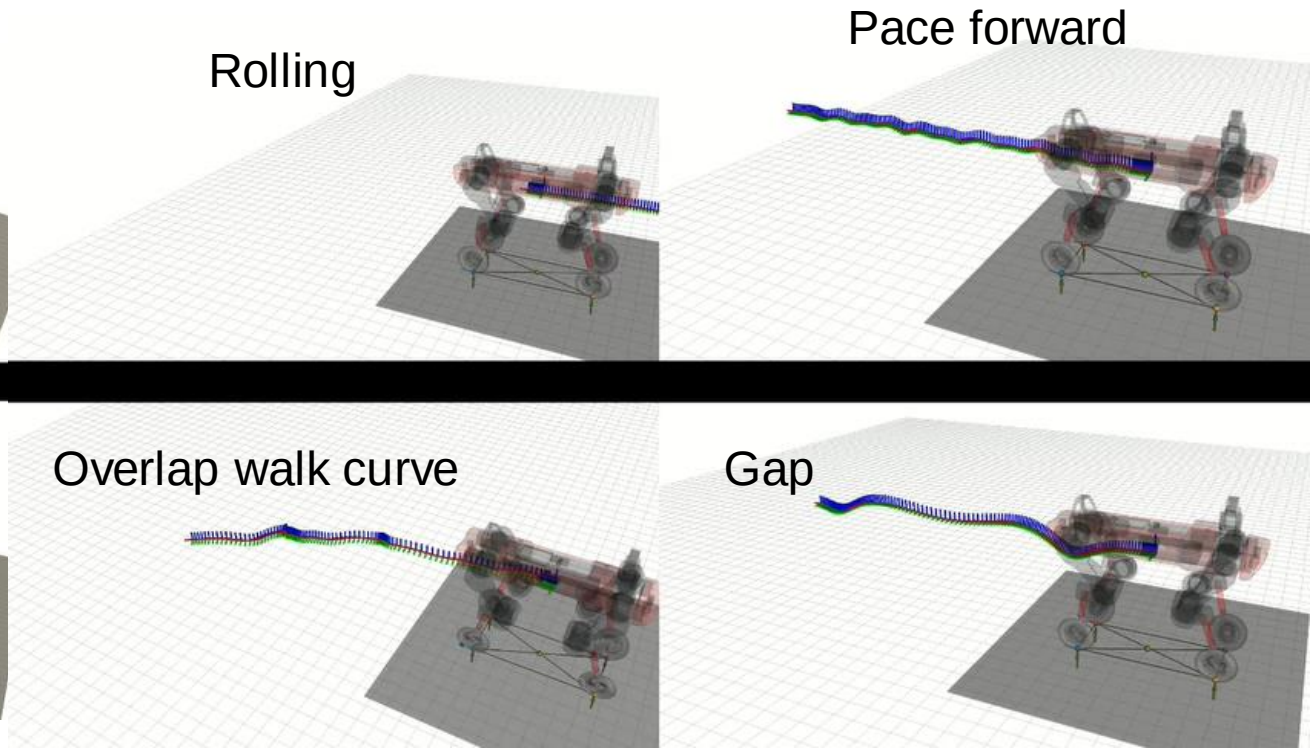


Fig. 2 MPC optimized trajectories computed on ocs2

Experiment Demonstrations

Simulation Results

Gap

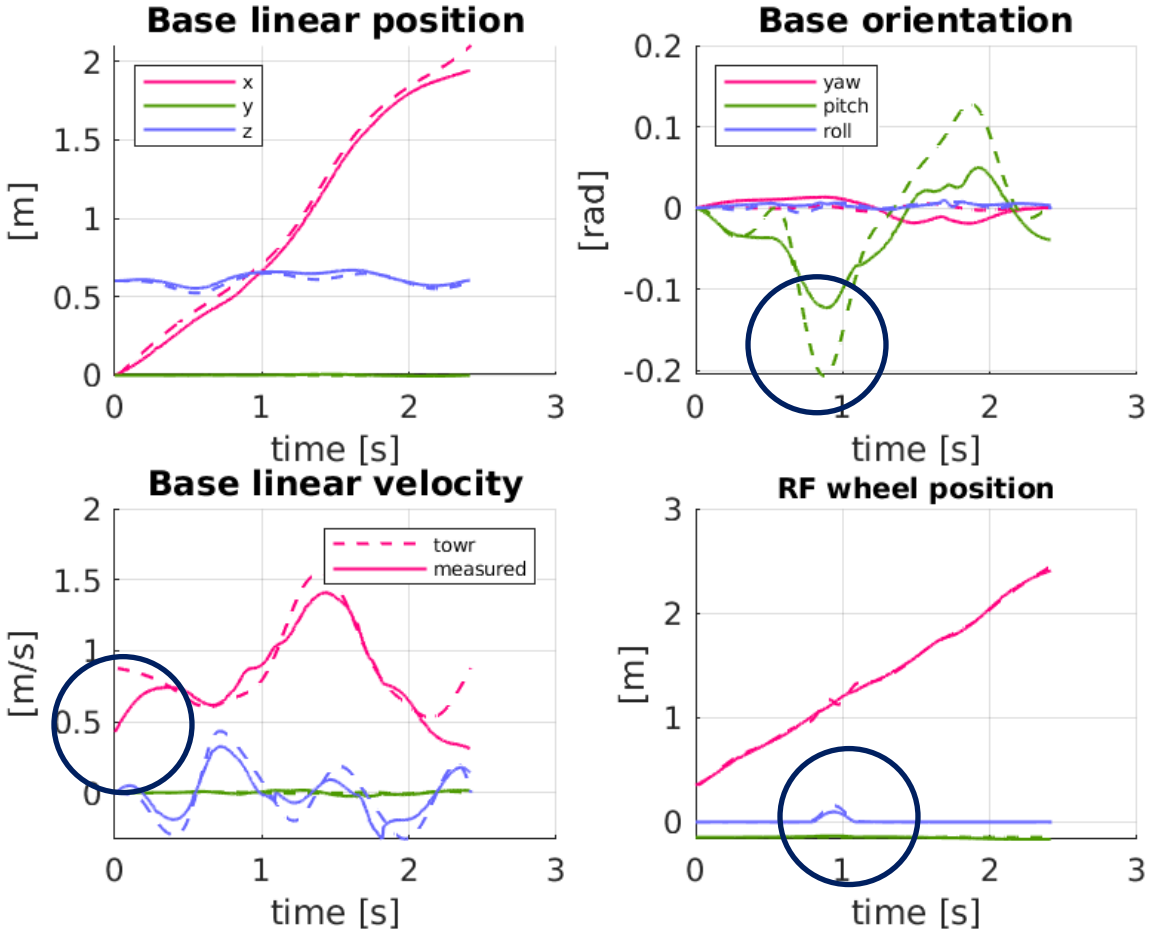
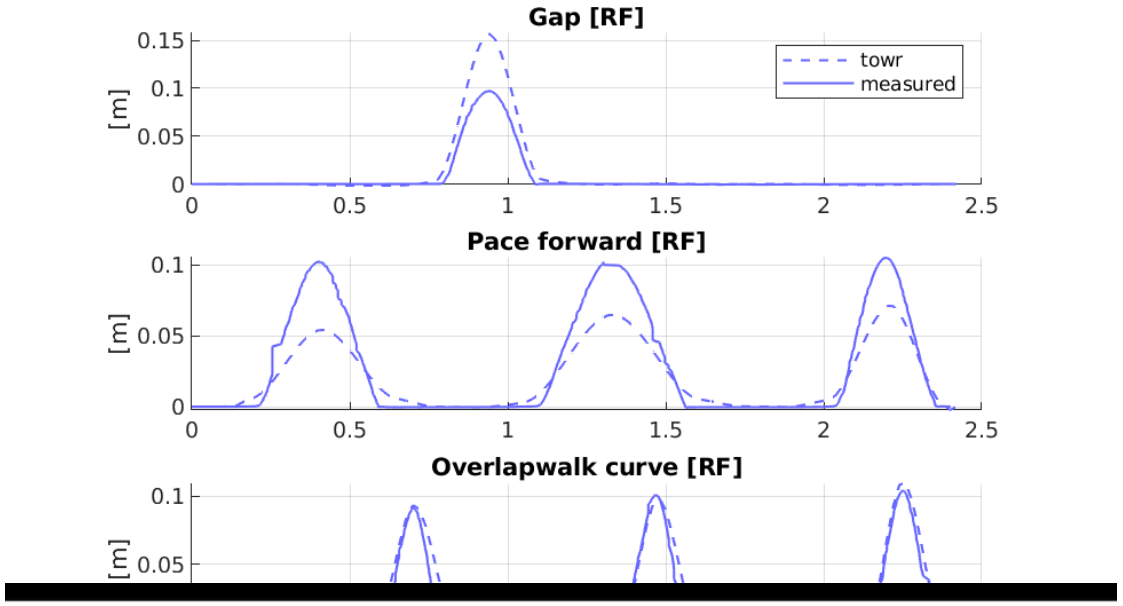
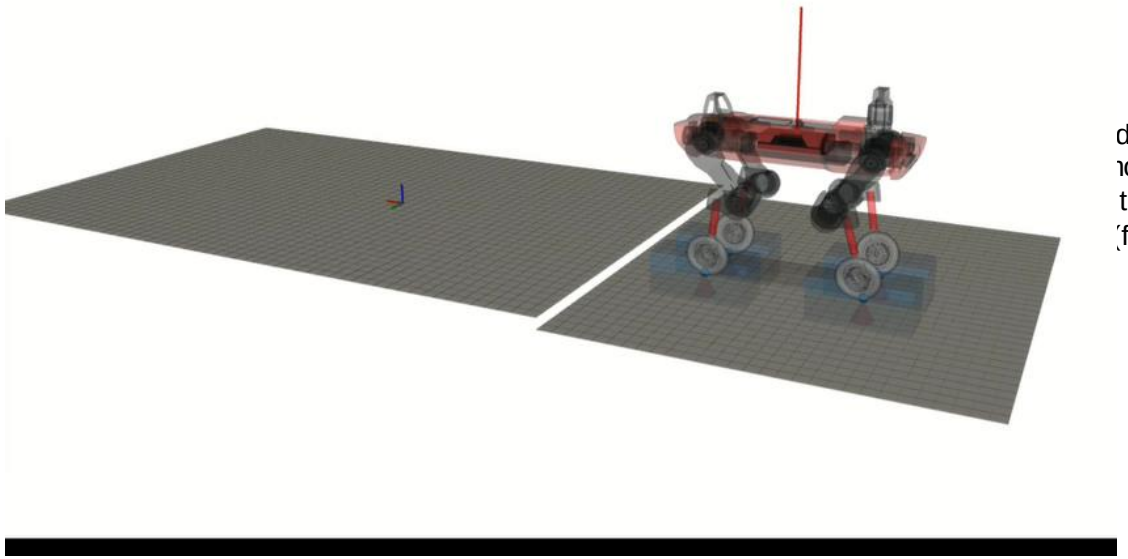


Fig. 5: The desired trajectory computed by towr (dashed lines) and the measured positions (full line)





d height
notion
the
(full line)

Hardware Results

Gap

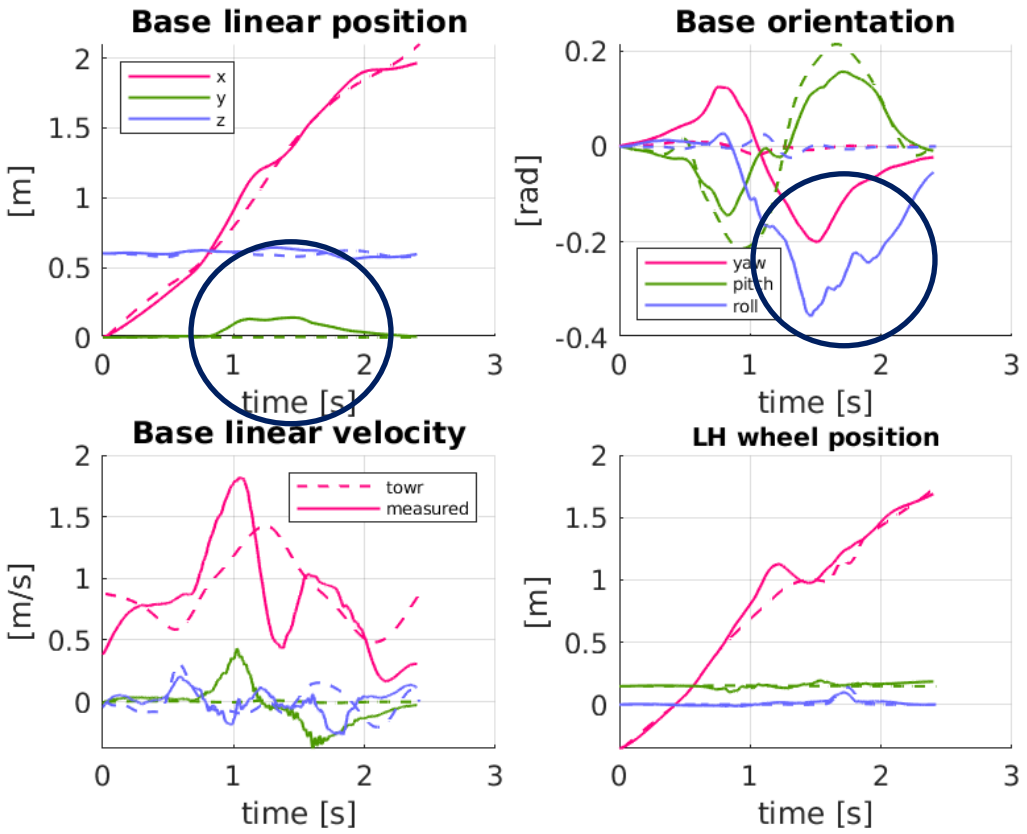


Fig. 8: Trajectories comparison

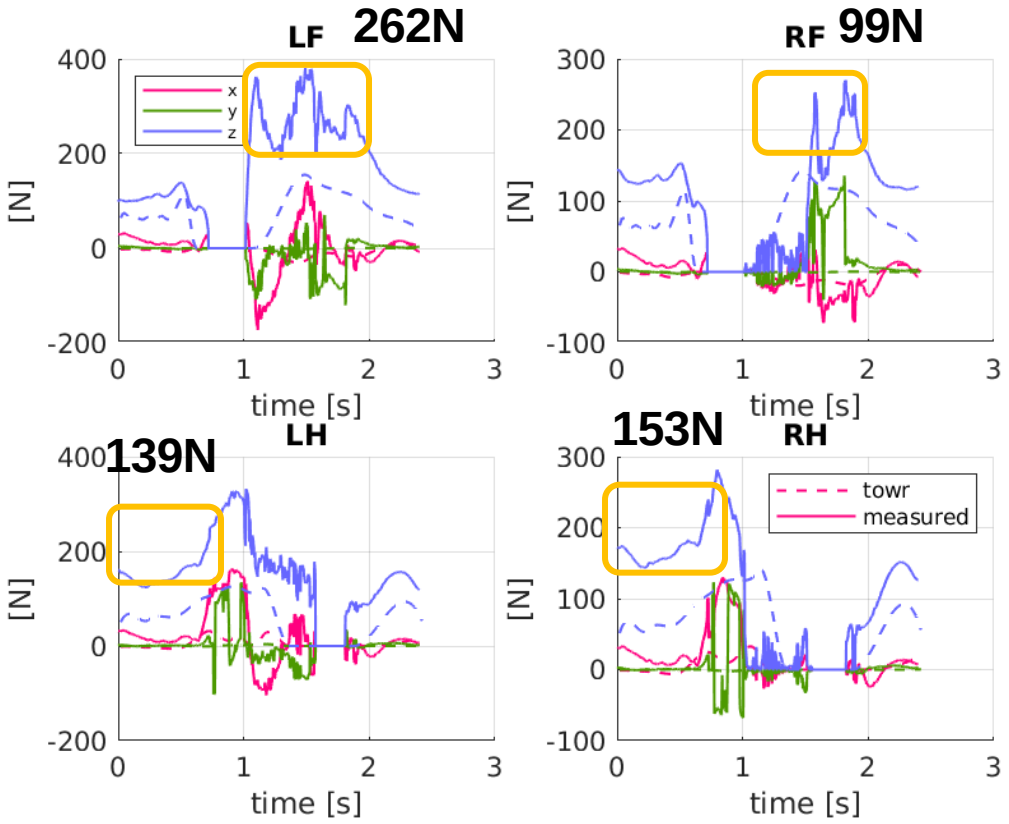


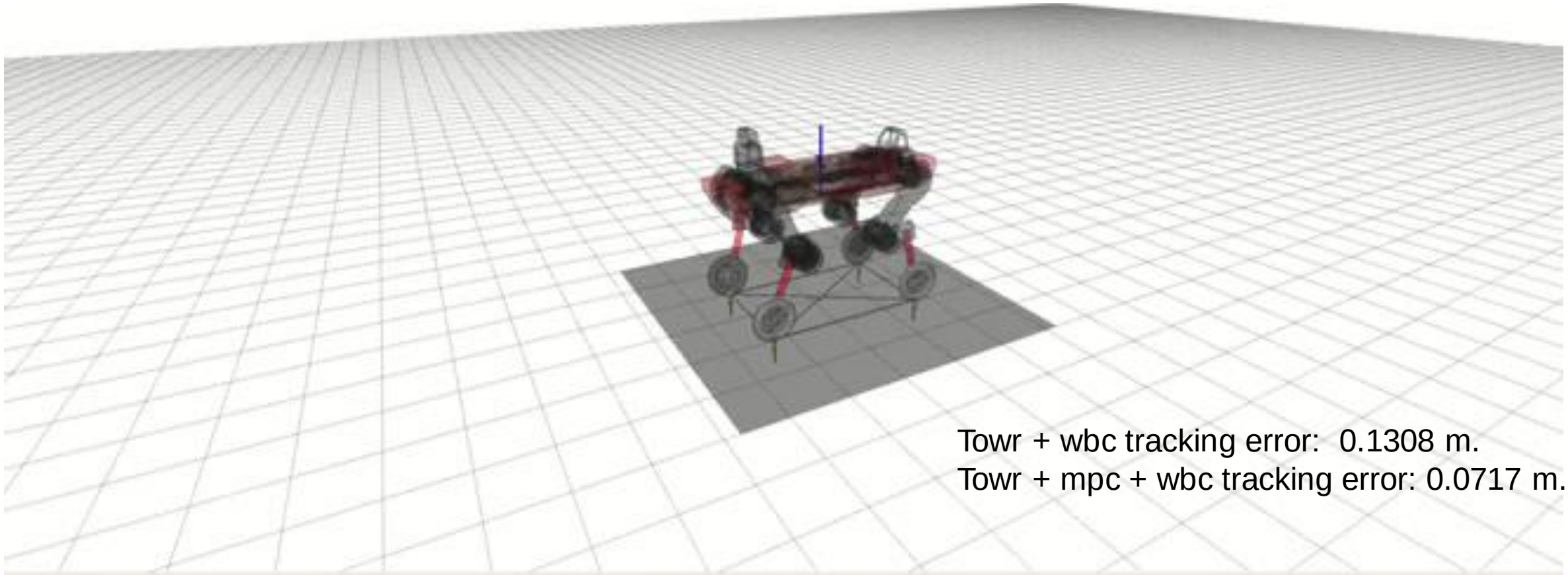
Fig. 9: Contact forces

Tracking Performance

	Mean Euclidean Distance [m]
Gap (Experiment)	0.0862
Gap	0.0600
Pace forward	0.0749
Overlap walk curve	0.0588
Trot forward	0.0717

Table 2.1: Tracking Performance of Motions (Base)

Why We Need MPC



Trot: towr + WBC

Outlook

1. Explore the tough terrains.

2. Do we really need a perfectly feasible trajectory?
   - Towr: run the trajectory optimization a couple of iterations would already give a “close to feasible” trajectory, MPC will correct it.
   - Other algorithms, for example, learning based methods

Q&A