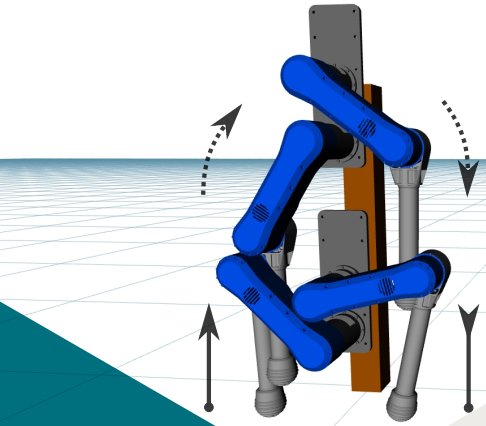

Optimal Design of Agile Jumping Maneuvers for a Single Leg System

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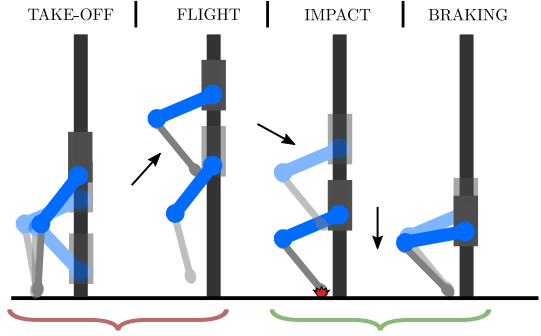
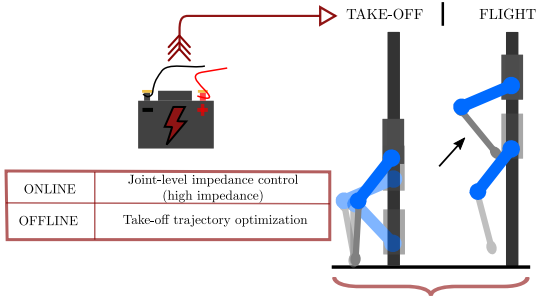
Experimental setup:

- 2 d.o.f **electrically-powered**, **torque-controllable** quadruped leg prototype, $50:1$ gear ratio
- 1 d.o.f. sliding guide
- 25 Ah, 51.2 V **battery** unit, 100 A peak discharge current
- dedicated **power sensing setup** for measuring regenerative power

Jump decomposed into

- Take-off + flight
- Impact + braking





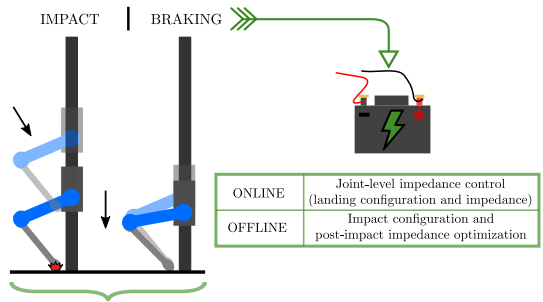
ONLINE	Joint-level impedance control (high impedance)
OFFLINE	Take-off trajectory optimization

Optimal **thrust trajectory** (first TO):

- Maximizing **apex height**
- Minimizing **optimization-to-reality gap**:
  - Accurate **actuation models**
  - Solution **refinement** + jerk-yank **regularization**

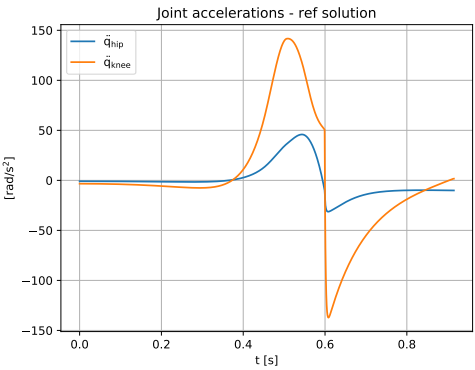
Optimal **landing configuration** + braking **joint impedance** setpoints (second TO):

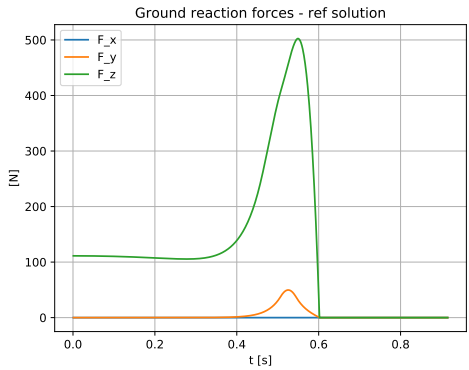
- Minimizing **ground impact**, maximizing **regenerated energy**, exploiting accurate
  - **actuation** models
  - **energy flow** models
- **Coupled** with first TO through
  - Foot velocity @ touchdown



Jerk and yank regularization promotes **feasible** solutions →

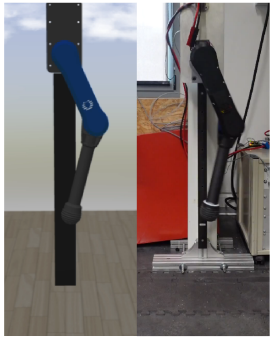
Resulting in **smooth** TO inputs:





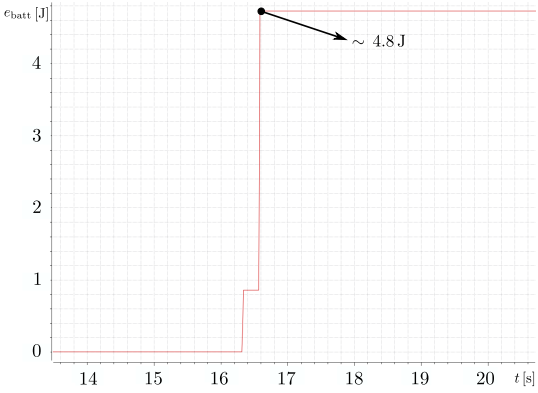
Optimal take-off trajectory **replay**:

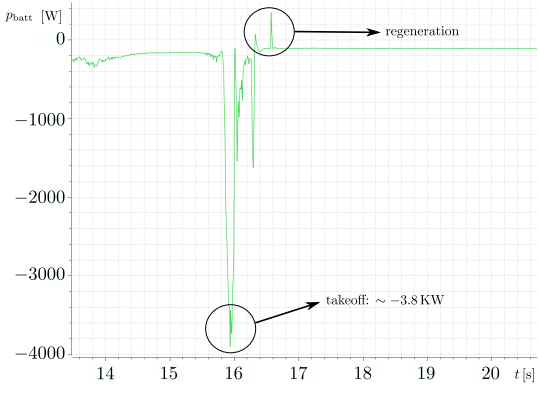
Reduced optimization-to-reality gap:



Measured regeneration @ touchdown:

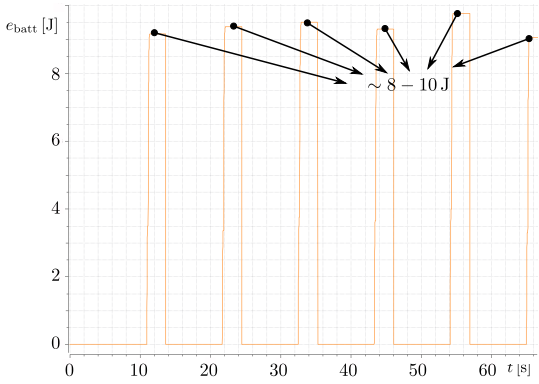
- **optimal** take-off
- **not-opt.** configuration/impedance
- **real** robot

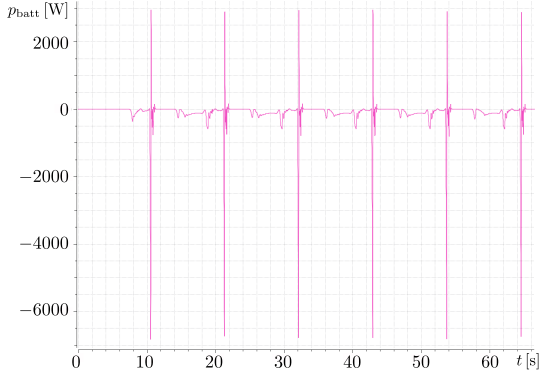


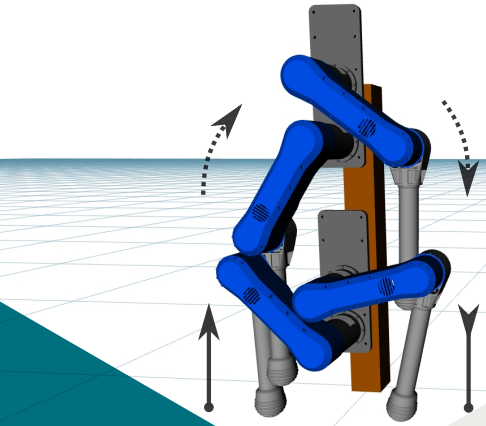


Estimated regeneration @ touchdown; successive jumping test:

- **optimal** take-off
- **opt**. configuration/impedance
- **simulated** robot







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