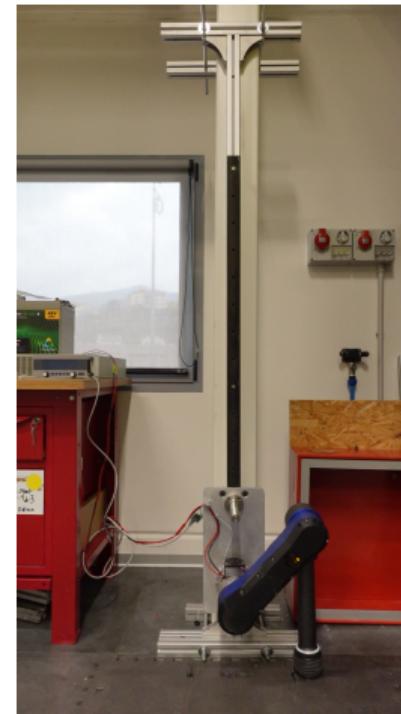


Optimal Design of Agile Jumping Maneuvers for a Single Leg System

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Laurenzi and Nikos G. Tsagarakis

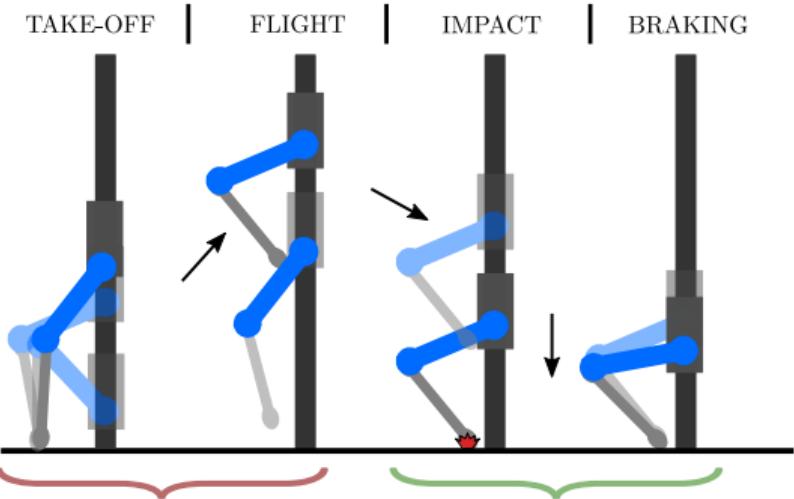
Experimental setup:

- ▶ 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
- ▶ peak torque: 112 N m
- ▶ peak velocity: 18.8 rad/s
- ▶ peak current: 50 A

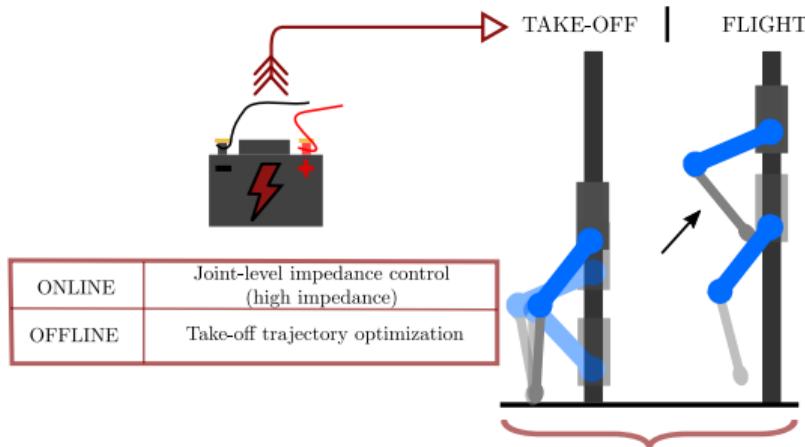


Jump decomposed into

- ▶ Take-off + flight
- ▶ Impact + braking



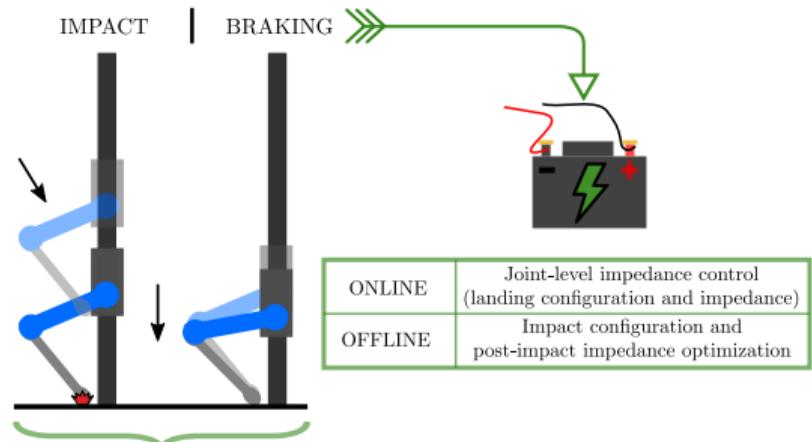
Optimal thrust trajectory (first TO):



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

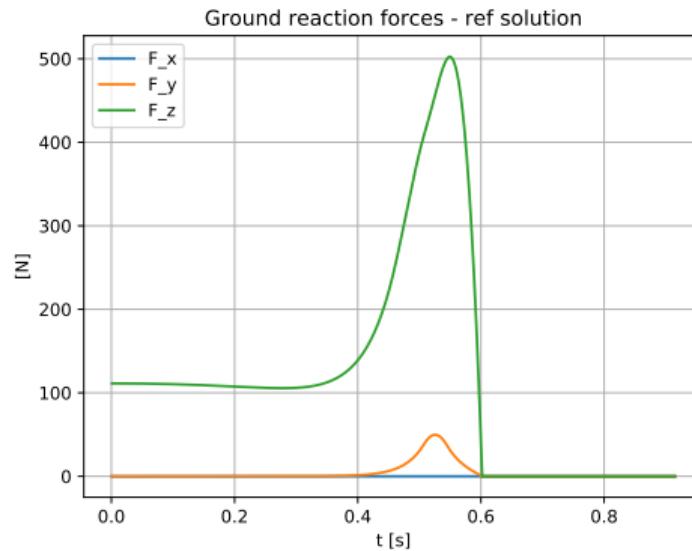
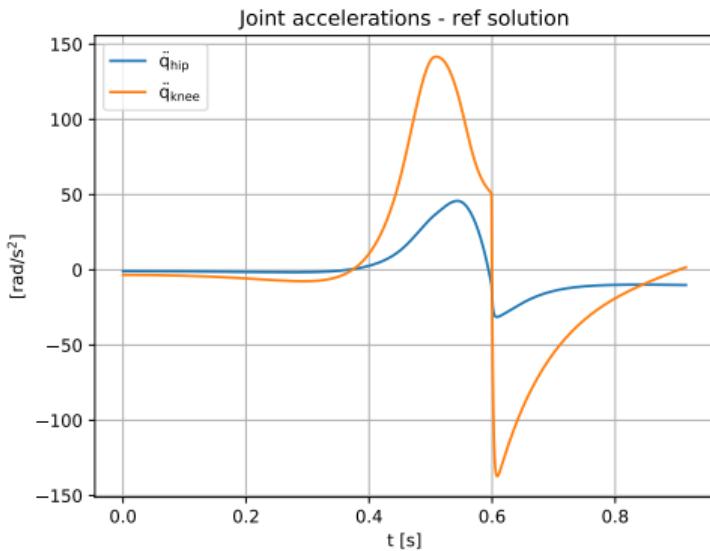
Optimal landing configuration + braking joint impedance setpoints (second TO):

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



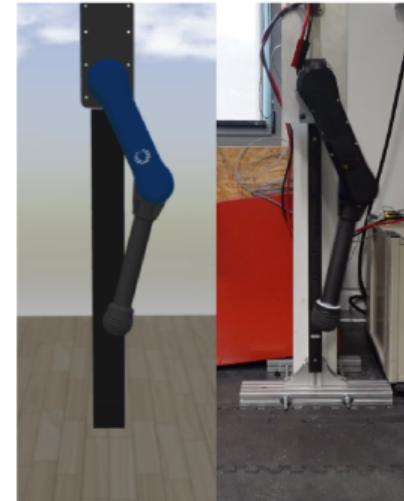
Jerk and yank regularization promotes feasible solutions →

Resulting in smooth TO inputs:



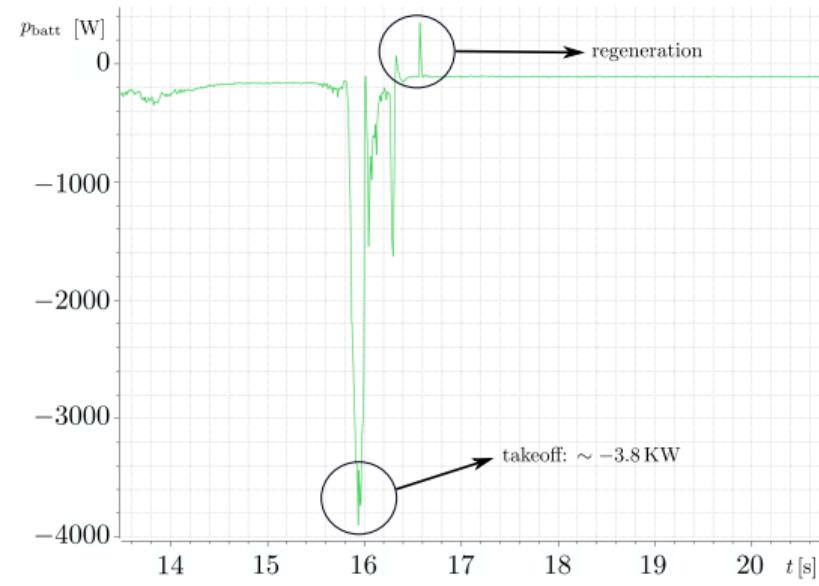
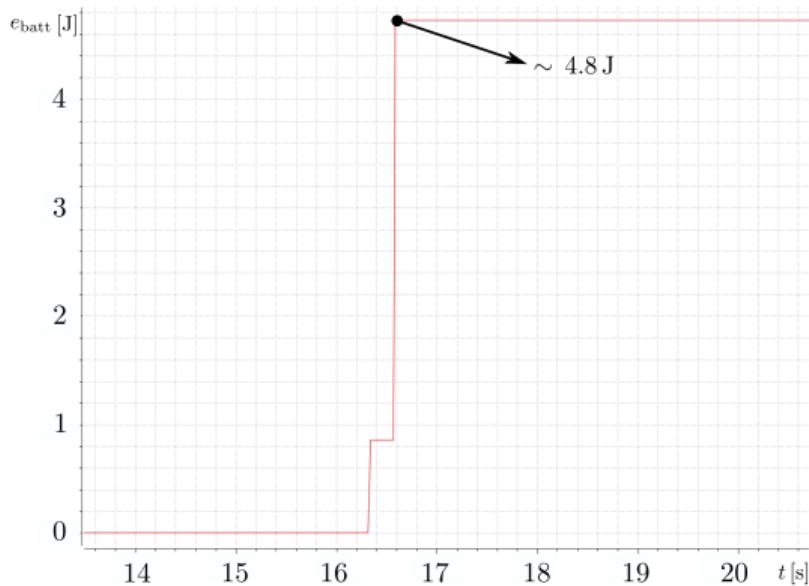
Optimal take-off trajectory **replay**:

Reduced optimization-to-reality gap:



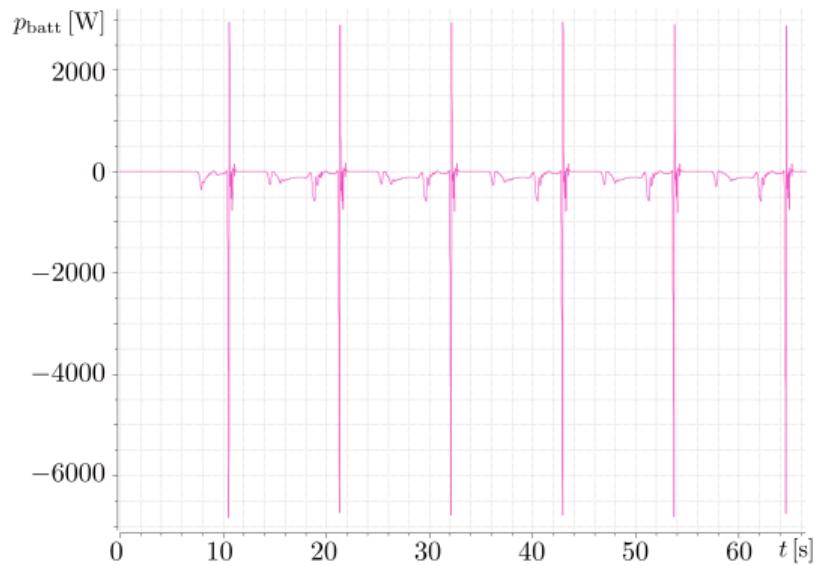
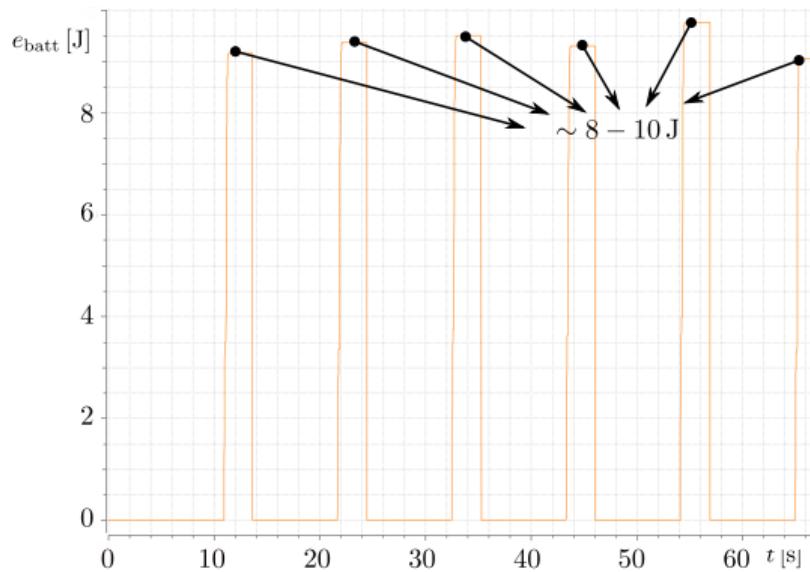
Measured regeneration @ touchdown:

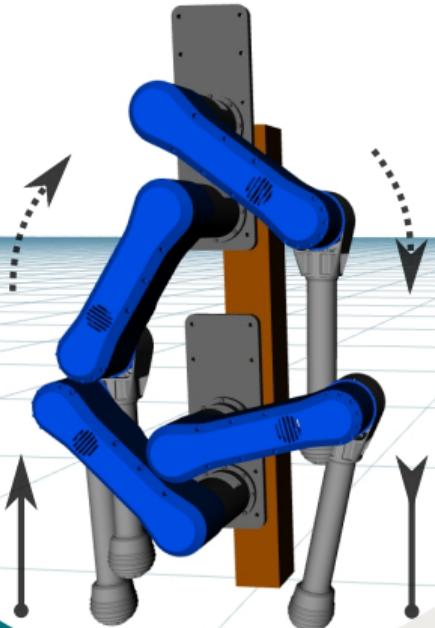
- ▶ optimal take-off
- ▶ opt. configuration/impedance
- ▶ real robot



Estimated regeneration @ touchdown; successive jumping test:

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





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