Optimization of Gaits with a Soft Contact Model

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Motivation
Observable foot-compliance during ground interaction

Soft Contact Model
- C1-continuous in $\delta_N, \delta_N$
- smoothing coefficient $\delta$
- no sticking forces: $\lambda_N \geq 0 \quad \forall \delta_N, \delta_N$

Hard contact model
- rigid body (hybrid dynamics):
  - no foot deformation $\delta_N \geq 0, \delta_T = 0$
  - holonomic non-slipping constraint in stance

Model Verification
Simulation results of RAMbi (squatting)
- deformations ($\delta_T, \delta_N$) of a single foot
- measured, hard, soft

Soft Contact Model
- contact invariant
  (single-phase optimization)
- about twice as fast
- requires fewer mesh points

Contact models in gait optimization:
- hard contact model
- soft contact model

Conclusion
The soft contact model is showing substantial compliance
- resembles experiments much closer than the rigid contact model

A good initial guess is essential for both contact models

References

Gait Optimization
Both contact models were implemented for a monopedal robot
- fixed horizontal speed in periodicity constraints

Objective function:
- thermal losses in motors
Initial guess:
- upright standing trajectory

Transcription
Direct collocation
- Hermite-Simpson splines
(similar to Frost [Ayonga 2017])

Implementation
- multi-phase (hard contact model)
- exploits sparse structure, analytic gradients
- mesh refinement