Contact-aware Control of Dynamic Manipulation

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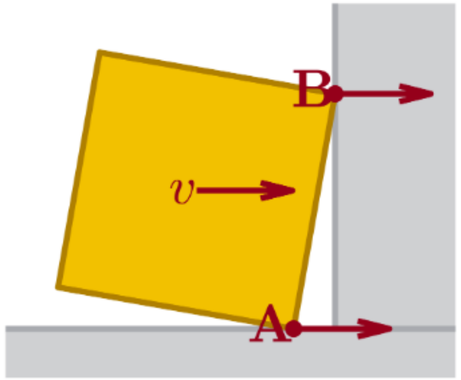
Physics-based Modeling and Control



Quasi-static modeling

- Integrate understanding of underlying velocity control to quasi-static models
- Created unified quasi-static model for pushing, grasping, and jamming.

Set-valued multi-contact simulation

- Rigid bodies lead to non-uniqueness, but simulators bias toward a single solution
- Linear complementarity problem to capture set of potential solutions

Contact-aware control

- Rather than try to identify and react to contact events, a simple, direct path from measured forces λ to control $u(x, \lambda)$

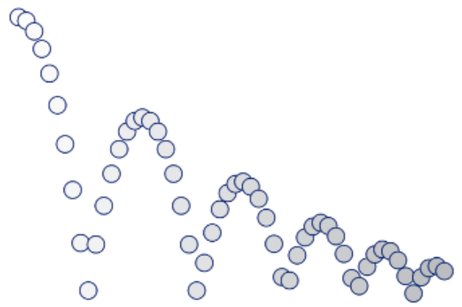
Linear complementarity framework can also verify ReLU neural networks

Halm and Posa. *A Quasi-static model and simulation approach for pushing, grasping, and jamming*. WAFR, 2018.
Halm and Posa. *Modeling and analysis of non-unique behaviors in multiple frictional impacts*. RSS, 2019.
Aydinoglu, Preciado, and Posa. *Contact-Aware Controller Design for Complementarity Systems*. ICRA, 2020.
Aydinoglu, Fazlyab, Morari, and Posa. *Stability Analysis of Complementarity Systems with Neural Network Controllers*. HSCC, 2021.

Physics-inspired learning

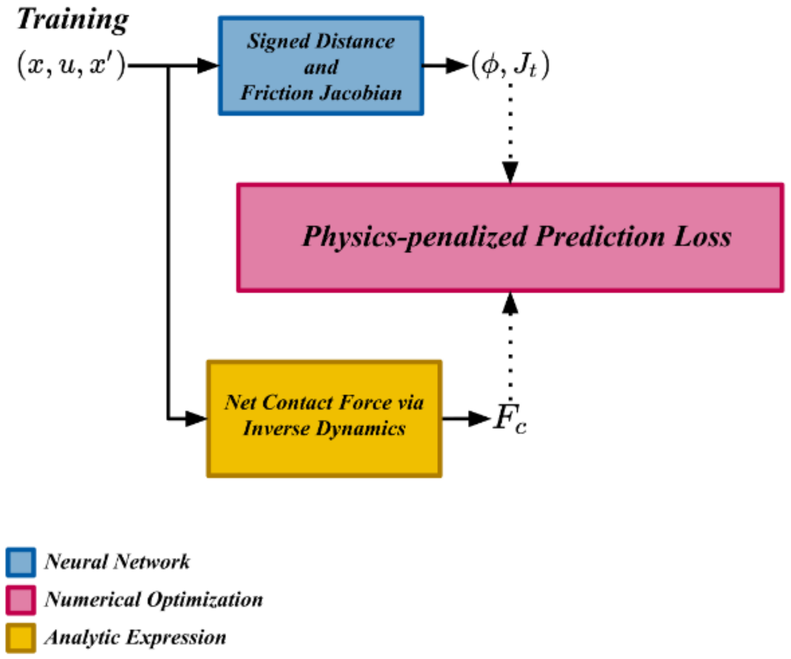
Deep neural networks are biased to find the simplest function $\hat{f}$ which explains the motion.

$$x' = f_\theta(x)$$



ContactNets: physics-inspired representation and learning of discontinuous dynamics

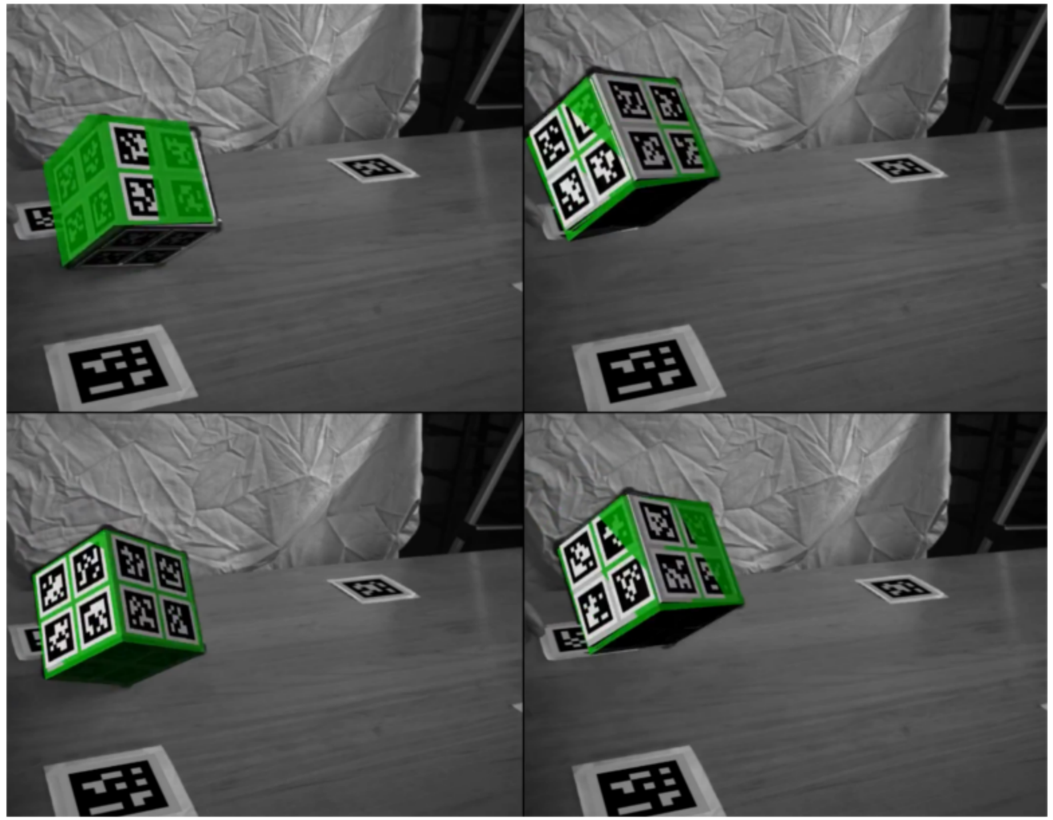
- Implicit representation of discontinuities
- Well-conditioned training process
- Trained without tactile sensing or mode estimation

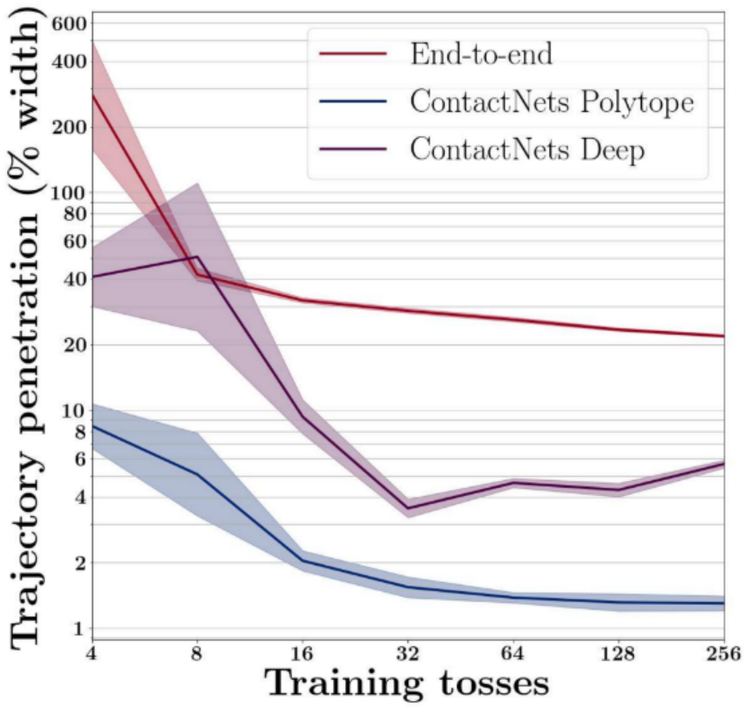


Pfrommer, Halm, and Posa. *ContactNets: Learning of Discontinuous Contact Dynamics with Smooth, Implicit Representations*. CORL, 2020.

Parmar, Halm and Posa. *Fundamental Challenges in Deep Learning for Stiff Contact Dynamics*. Under review.

Physics-inspired learning





Trained on single-step prediction, accurate long term predictions from minimal data.

Pfrommer, Halm, and Posa. *ContactNets: Learning of Discontinuous Contact Dynamics with Smooth, Implicit Representations*. CORL, 2020.

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