

Accelerating Robotic Manipulation with Data-Enhanced Contact Mechanics

NRI PI meeting
October 29, 2018

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MCube Lab

NRI: Collaborative Research

Accelerating Robotic Manipulation with Data-Enhanced Contact Mechanics

PIs: Boots (GaTech), Mason (CMU) and Rodriguez (MIT)

Motivation

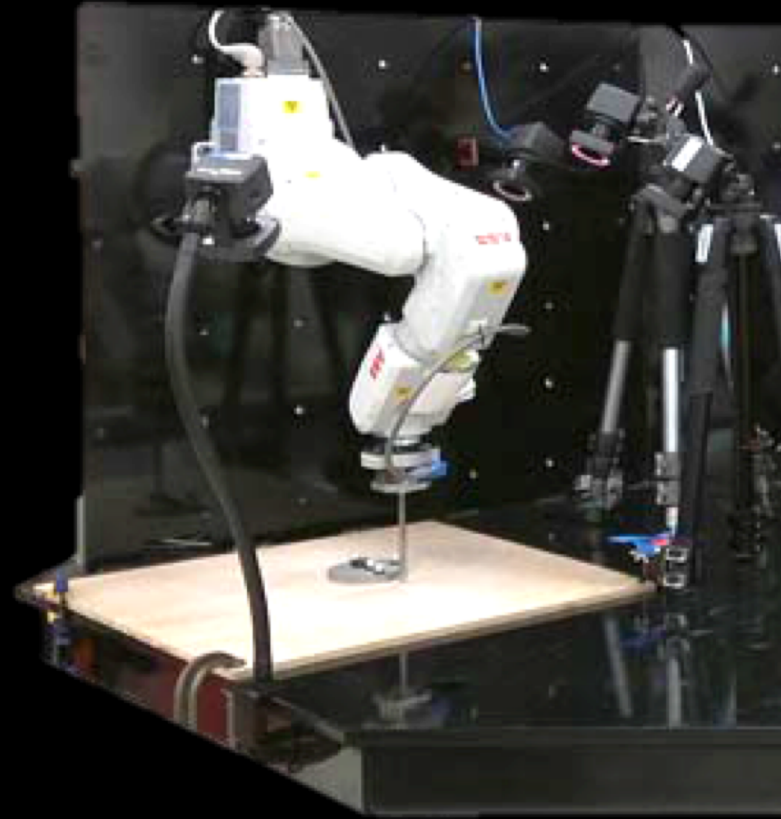
Reliable physical interaction requires empirical data.

Goals

1. How can we use data to **improve** contact models?
2. How can we use those improved models for **inference** and **control**?

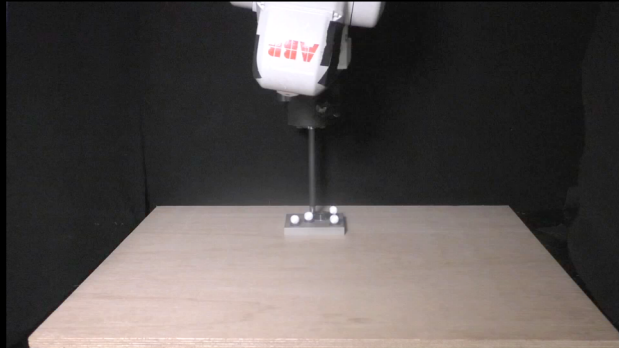
Key Challenges

Noise, non-smooth dynamics, hysteresis, deformation.



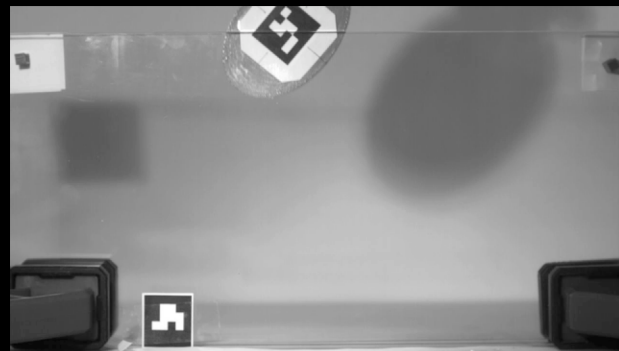


Experimental Datasets



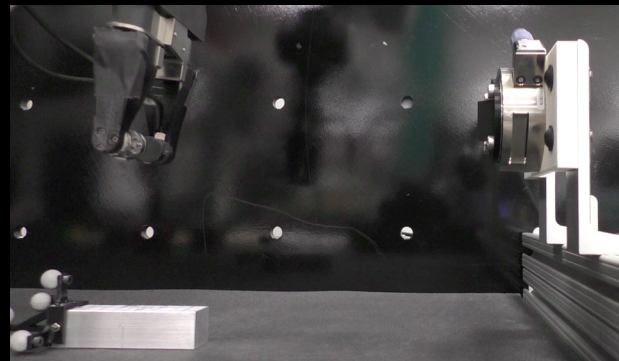
Planar Pushing

More than a Million Ways to be Pushed. A High-Fidelity Experimental Dataset of Planar Pushing IROS'16, by Peter Yu, Maria Bauza, Nima Fazeli, and Alberto Rodriguez. [Finalist Best Paper Award IROS'16](#)



Planar Impacts

Empirical Evaluation of Common Contact Models for Planar Impact ICRA'17, by Nima Fazeli, Elliott Donlon, Evan Drumwright, and Alberto Rodriguez.

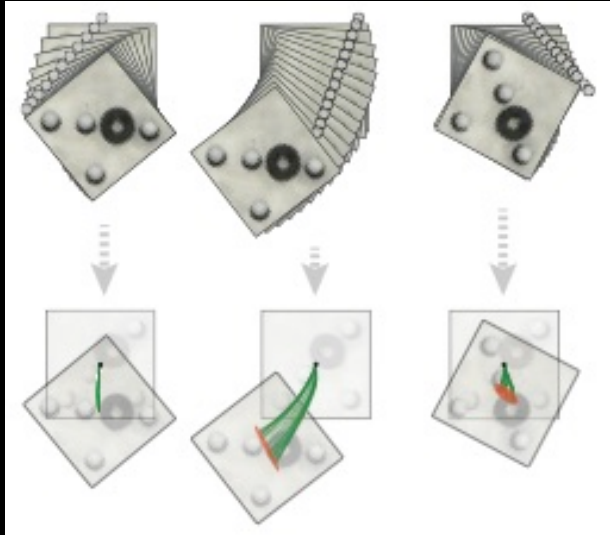


Prehensile Pushing

Experimental Validation of Contact Dynamics for in-Hand Manipulation ISER'16, by Roman Kolbert, Nikhil Chavan-Dafle, and Alberto Rodriguez.



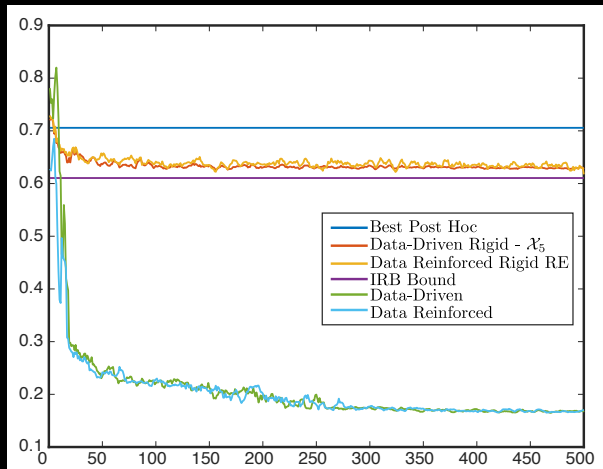
Mechanics Modeling



Planar Pushing

A Probabilistic Data-Driven Model for Planar Pushing ICRA'17, by Maria Bauza and Alberto Rodriguez.

- Explore **GPs** for modeling contact models.
- Improve analytical models after ~ 100 datapoints.
- Explicitly capture **uncertainty**.



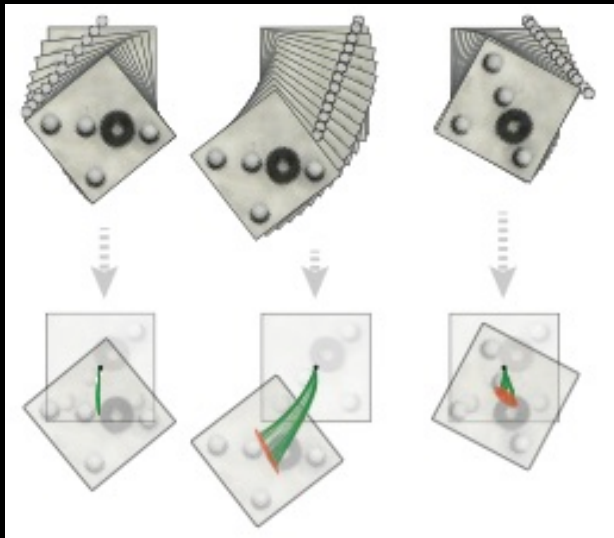
Planar Impacts

Learning Data-Efficient Rigid-Body Contact Models: Case Study of Planar Impact CoRL'17, by Nima Fazeli, Samuel Zapolsky, Evan Drumwright, and Alberto Rodriguez.

- Explore **GPs** for reinforce contact models.
- Efficient learning of **hybrid analytical + data-driven models**.
- 15-20 data points is enough to improve analytical models.



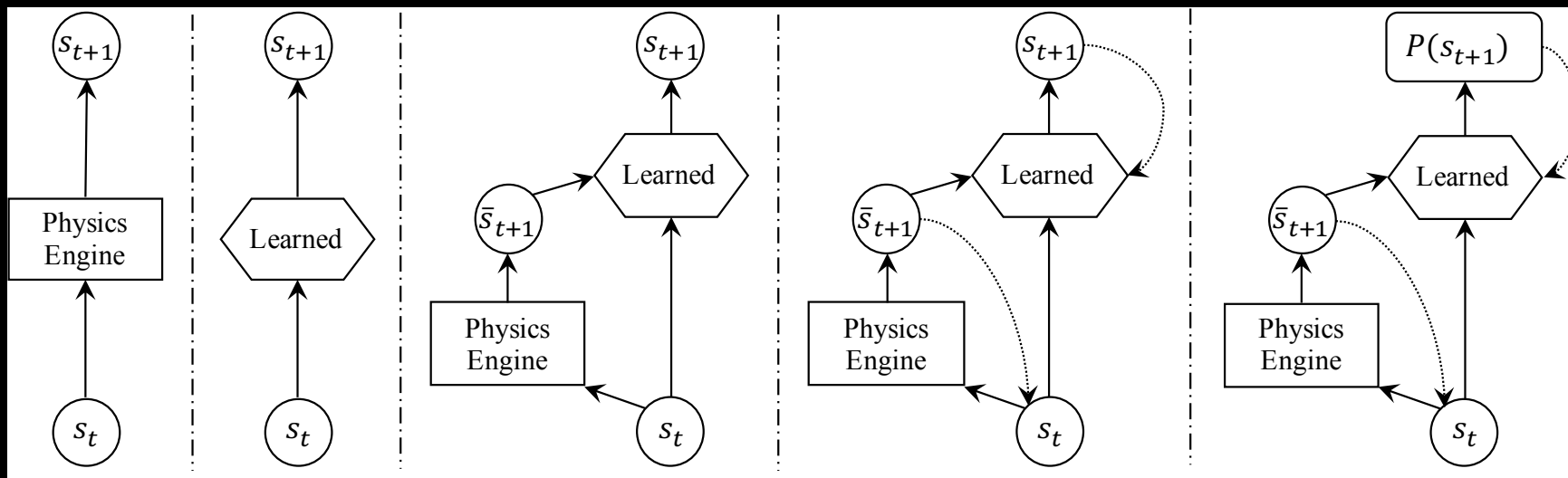
Dynamics Modeling



Planar Pushing

Augmenting Physical Simulators with Stochastic Neural Networks: Case study of Planar Pushing and Bouncing IROS'18, by Anurag Ajay, Jianjun Wu, Nima Fazeli, Maria Bauza, Leslie Kaelbling, Joshua Tenenbaum and Alberto Rodriguez, [Best Cognitive Paper Award IROS'18](#)

- Explore Stochastic Recursive Neural Networks to reinforce dynamics models.
- Outperform analytical and purely data-driven models.
- Explicitly capture [uncertainty](#).



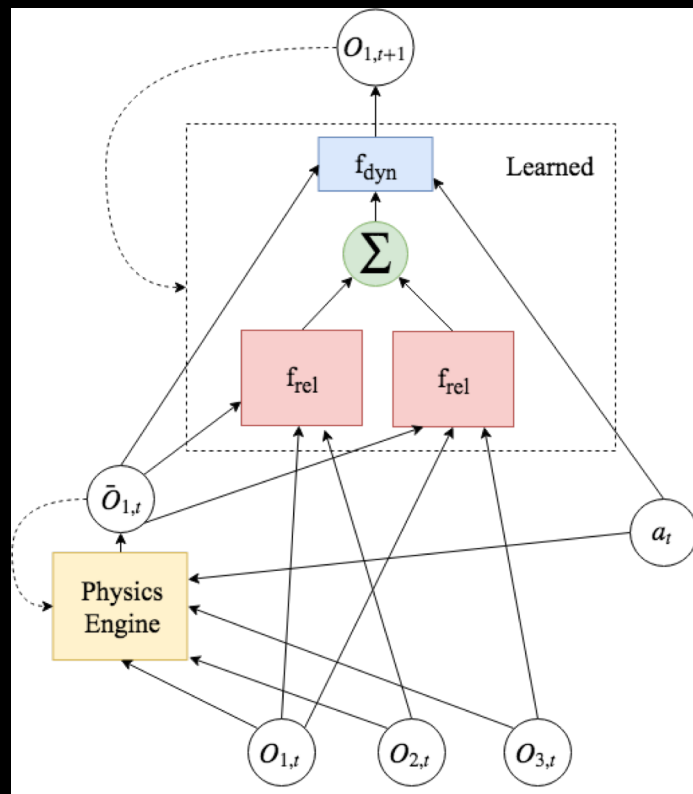


Control



Planar Pushing

Combining Physical Simulators and Object Based Networks for Control
ICRA'19, by Anurag Ajay, Maria Bauza, Jianjun Wu, Nima Fazeli, Joshua Tenenbaum, Alberto Rodriguez, and Leslie Kaelbling (under review)





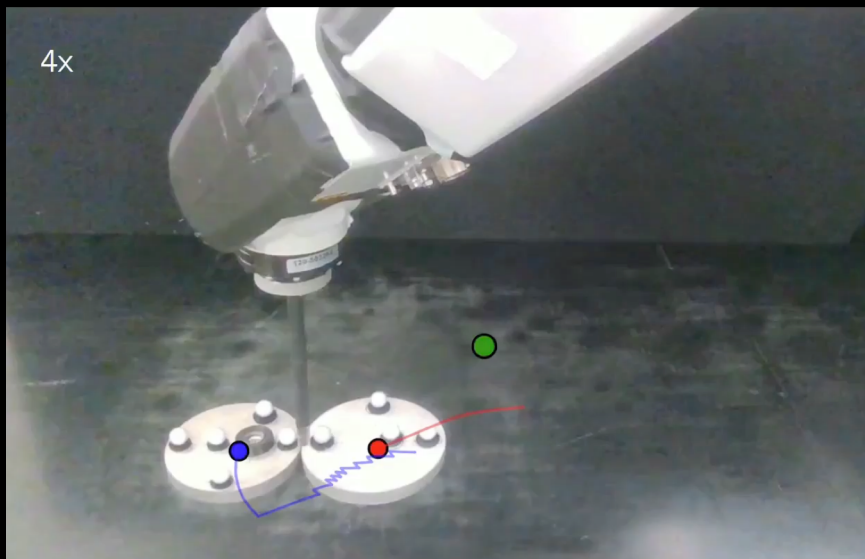
Control



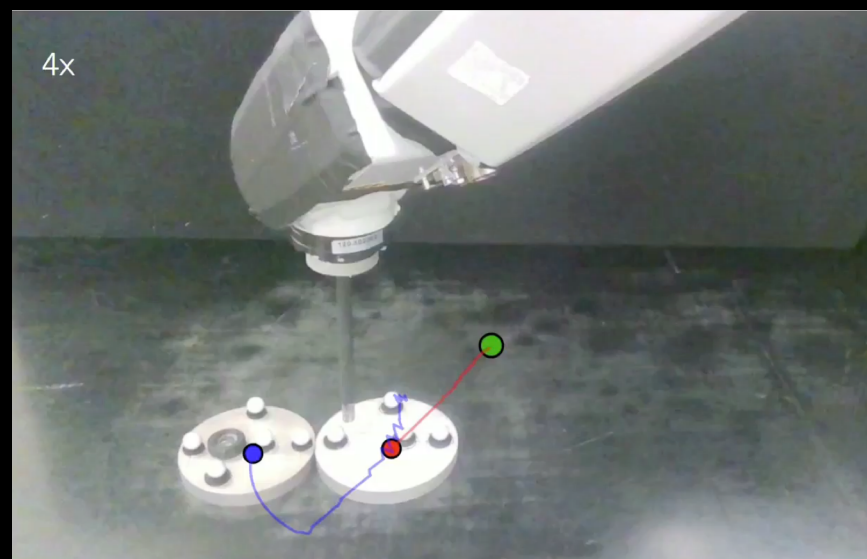
Planar Pushing

Combining Physical Simulators and Object Based Networks for Control
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- SAIN: Simulator Augmented Interaction Networks.
- More **efficient** learning and **generalization** by imposing an object-based representation.



Purely analytical



Data-reinforced

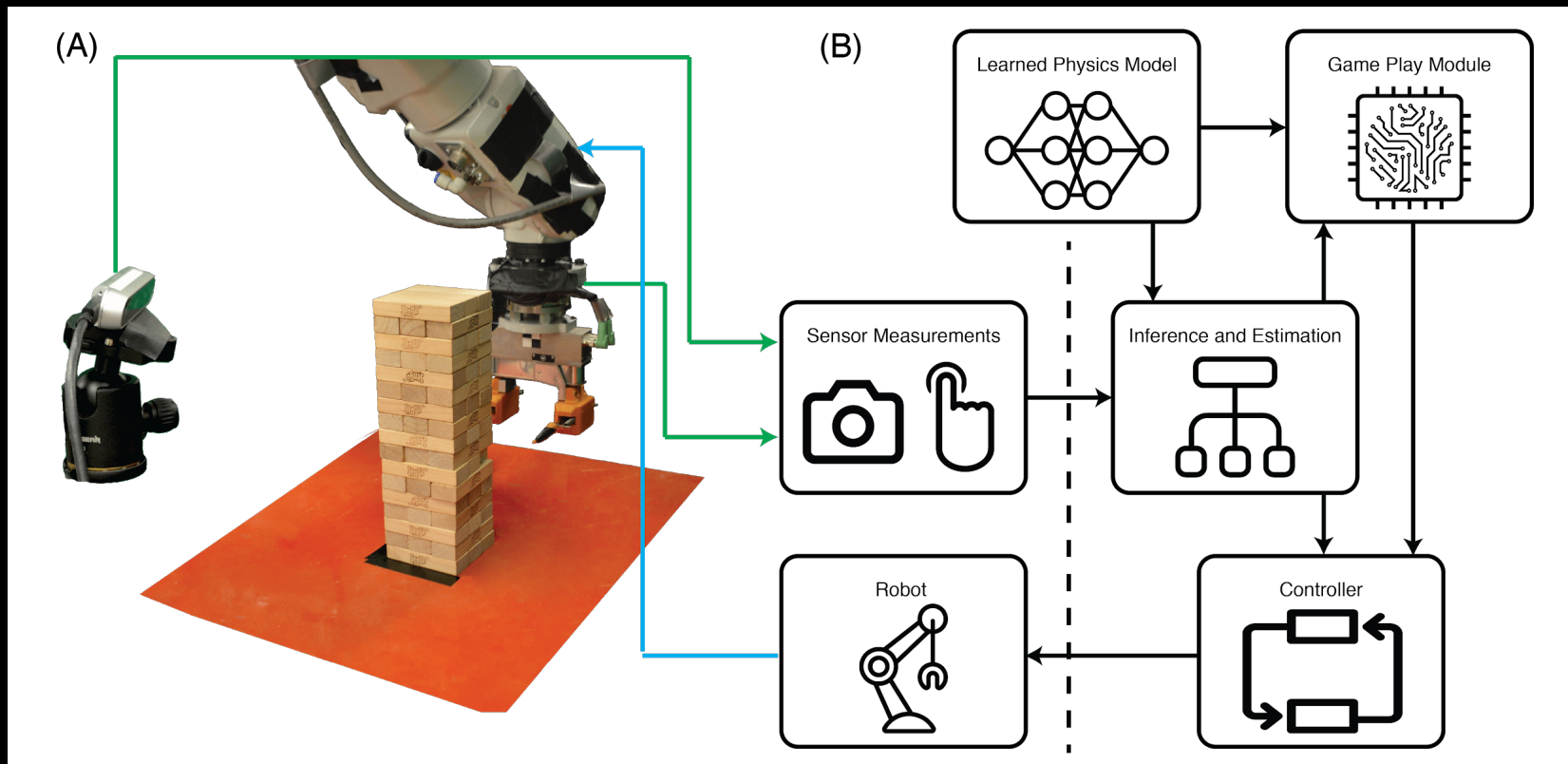


Inference and Control



Game of Jenga

See, Feel, Act: Learning Complex Manipulation Skills with Causal Structure and Multi-Sensory Fusion Science'19, by Nima Fazeli, Jiajun Wu, Miquel Oller, Zi Wu, Joshua Tenenbaum, and Alberto Rodriguez (under review)



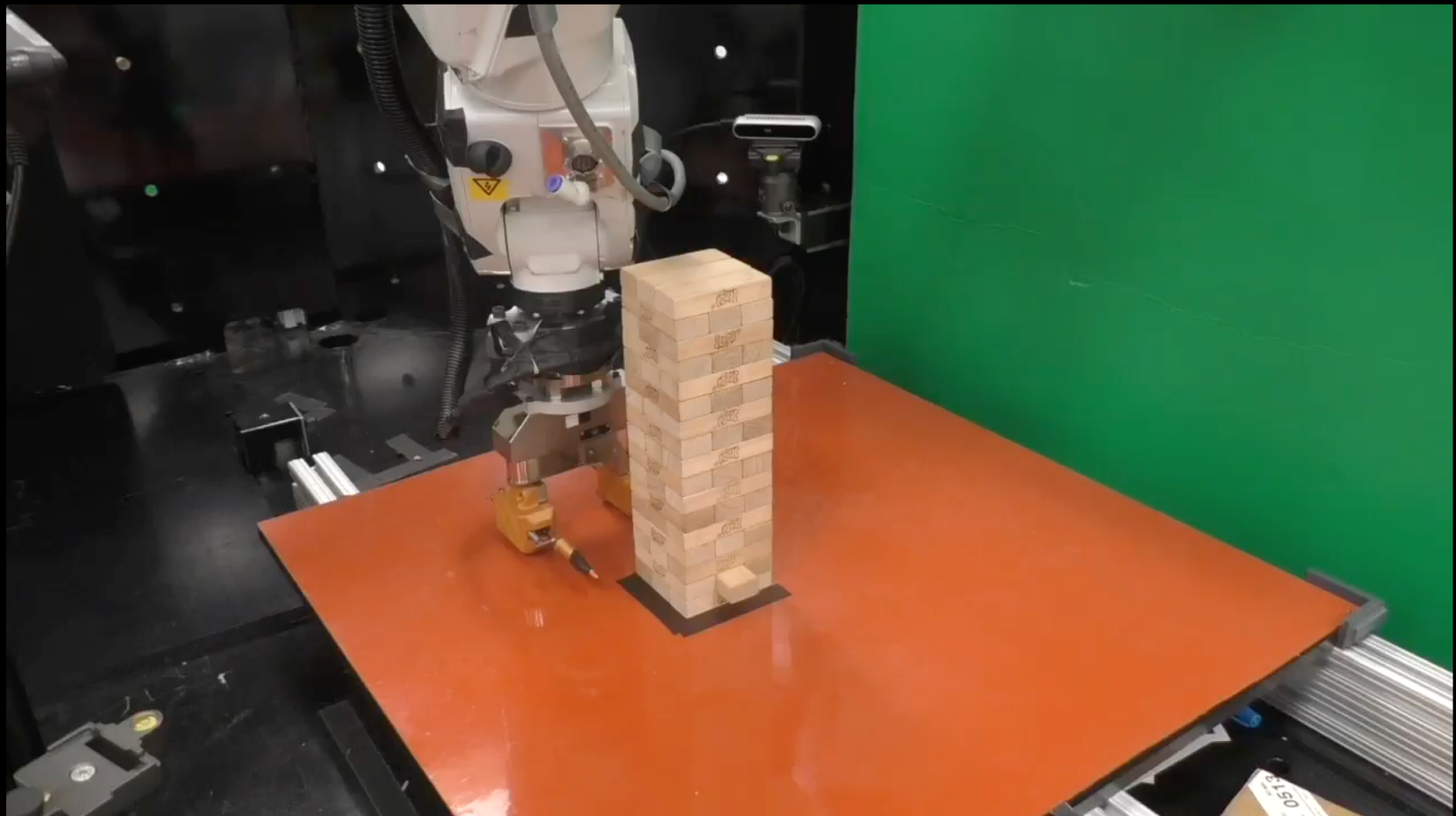


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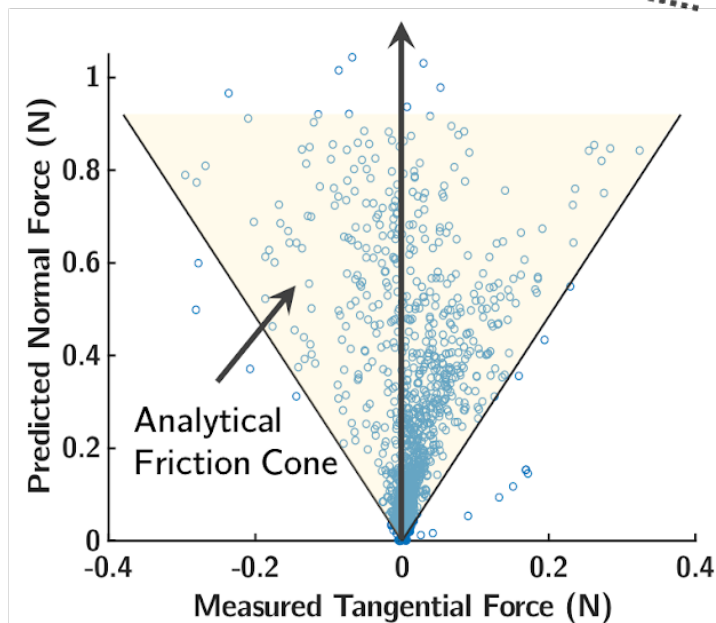
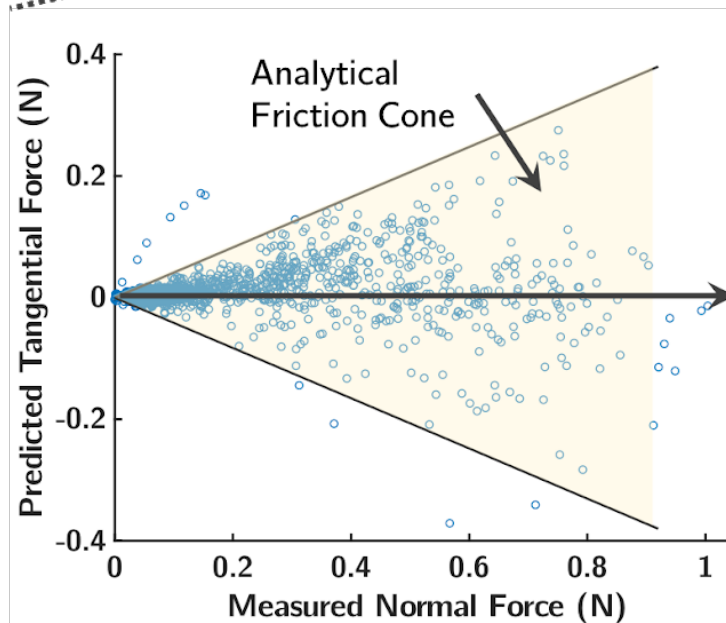
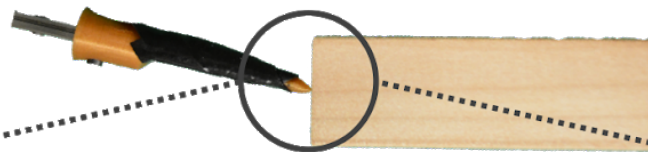
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Thanks!



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