Experiments with Frictional Contact

December 13, 2016 SIMPAR Grand Challenges in Robotic Simulation

> Alberto Rodriguez MIT Mechanical Engineering



Massachusetts Institute of Technology









What is this? Any takers?



Friction Cone



Contact forces from planar pushing









Friction Cone

|**||i**ī



Is this Coulomb's law?



Dataset Planar Pushing

- Surface material (4)



|||ii

https://youtu.be/tuXCHFnc7DY

More than a Million ways to be Pushed. A High Fidelity Experimental Dataset of Planar Pushing Peter Yu, Maria Bauza, Nima Fazeli and Alberto Rodriguez, IROS'16



Variability Planar Pushing

Other dimensions of variability

Location, direction, velocity ...





Variability Planar Pushing

|||iī

At the output ...

Distribution after 2000 pushes





How do we build trust in Simulators?

- Reduce confidence in predictions.
- Accuracy in the statistical sense.





|**|**|iī

How do we build trust in Simulators?

- Need empirical evaluation/benchmarking





14111

How do we make useful Simulators (for Robotics)?

- Exploit structure in noise.
- What is a realistic/computationally-efficient structure for that noise?
- How do we propagate it?





1111

How do we make **useful** Simulators (for Robotics)?

- Both soft and hard contacts are useful in robotics.



https://youtu.be/ZiqC9emBk00



How do we make **useful** Simulators (for Robotics)?

- Understandable.
- Sometimes things work but we do not entirely understand why.













Other Datasets: Planar Impact





LI ii

Evaluation of common impact models Mirtich, Wang-Mason, Anitescu-Potra Newton, Anitescu-Potra Poisson, Drumwright-Shell, ...

Empirical Evaluation of Common Impact Models on a Planar Impact Task Nima Fazeli, Elliott Donlon, Evan Drumwright and Alberto Rodriguez, ICRA'17 (under review)



Other Datasets: In-Hand Manipulation

Extrinsic Dexterity





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

Manipulation and Mechanisms @MIT



Massachusetts Institute of Technology

