
# Certified Grasping

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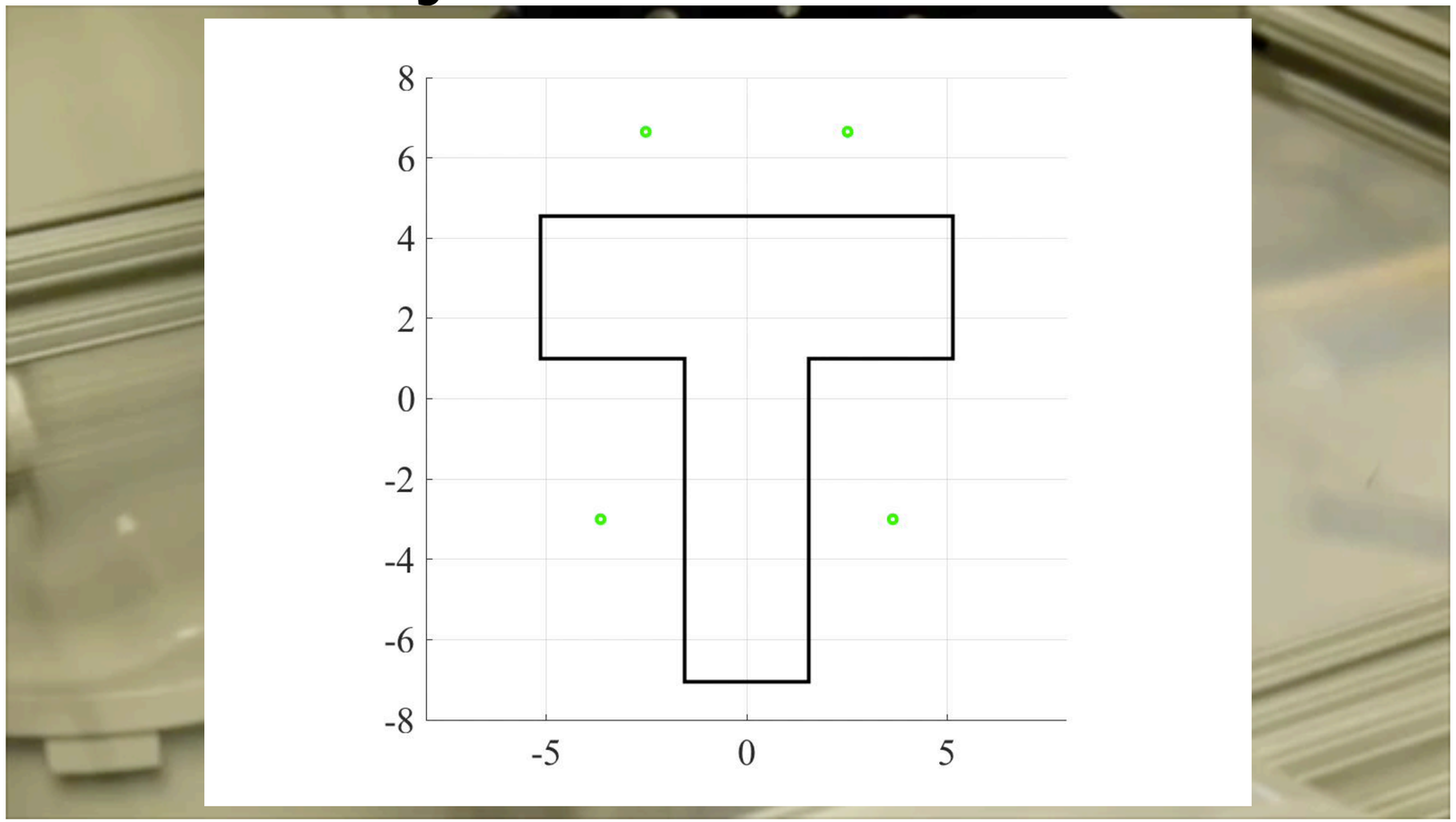
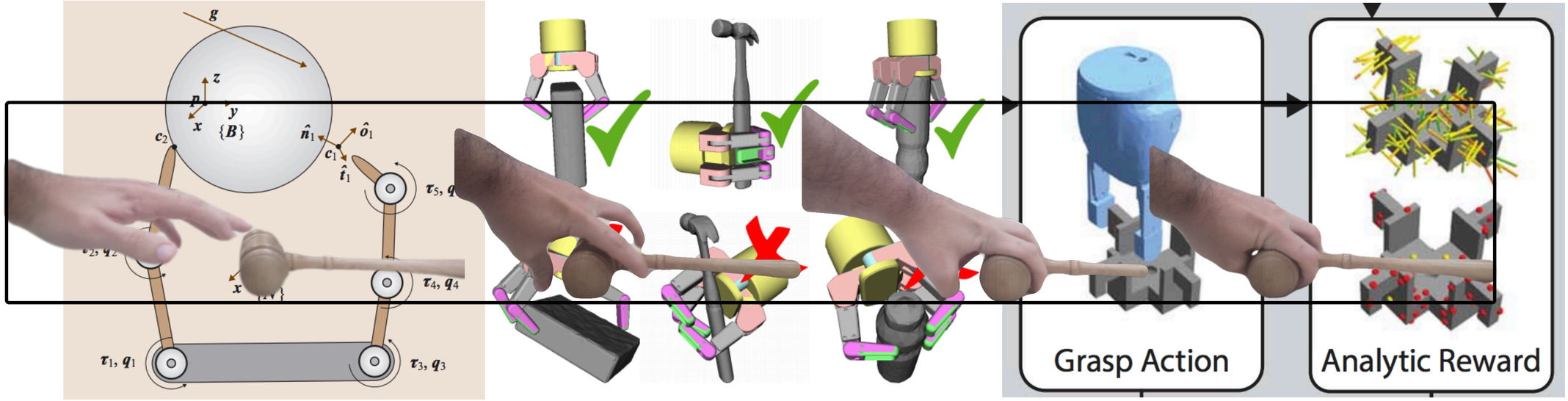
# Why certification?




[Zhou'17]

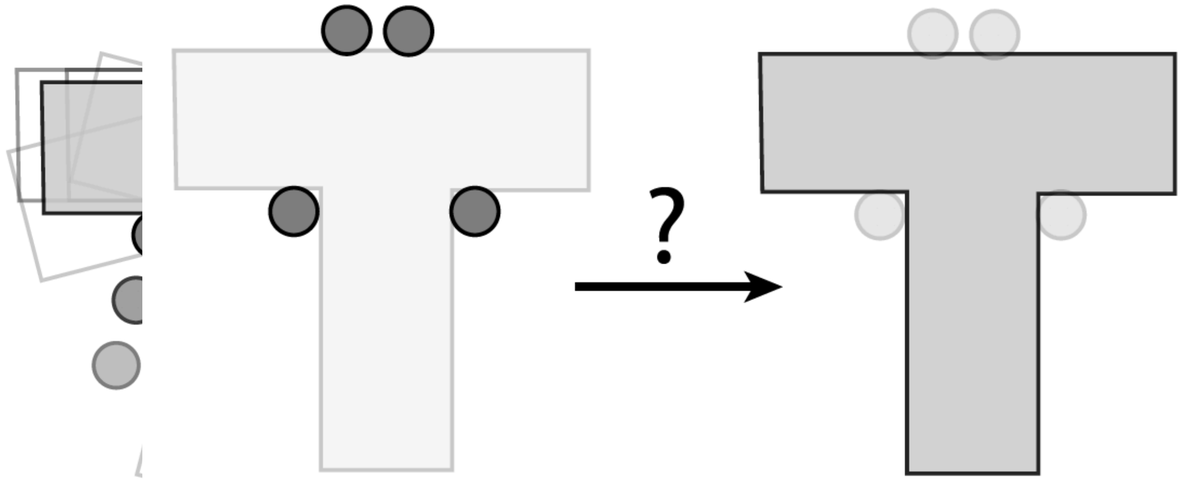
# State of the art




Grasping = process

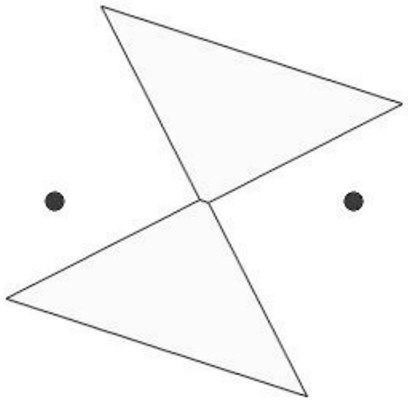
[Prattichizzo'08][Rubert'17][Mahler'19]

# Certificates for Grasping

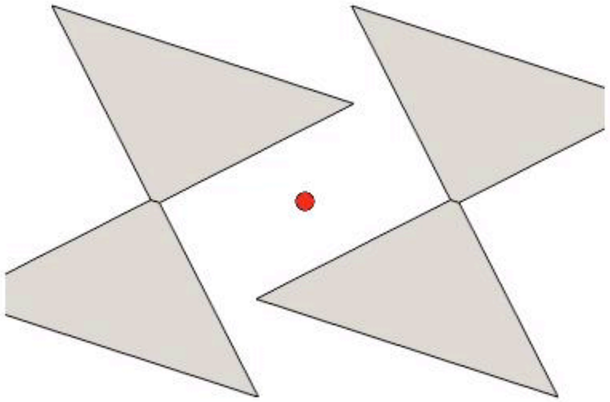



*Invariance (reachability) Observability (imaging)*

# Quick review



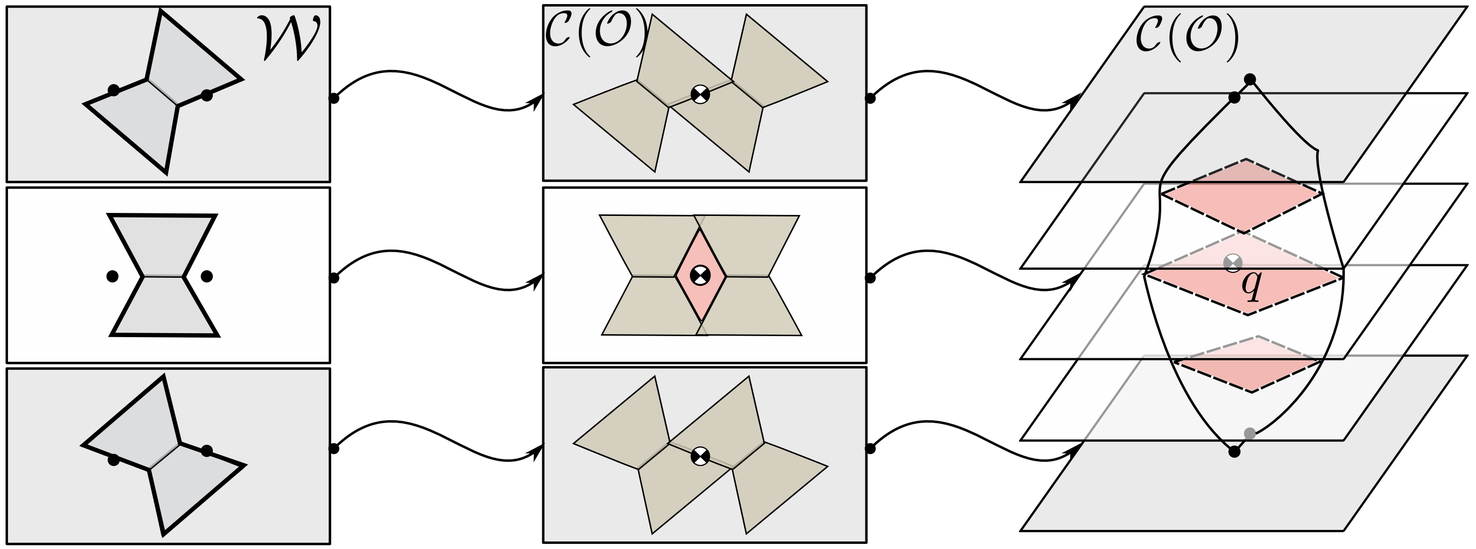
**Workspace**



**Free-Space**

***C-slice:*** set of free-space with constant orientation.

# Modeling

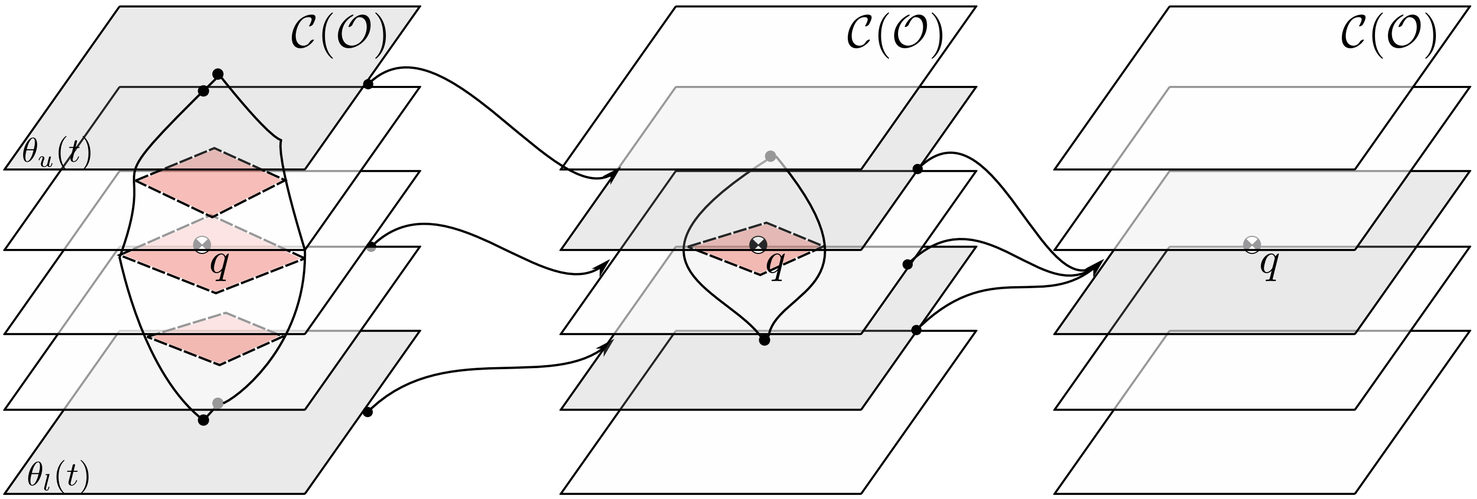



**Invariance (caging)**

- **Assumption:** object is polygon.
- Loops on each slice.
- Loops close at two orientations.
- Loops are connected.

*"A Convex-Combinatorial Model for Planar Caging"* by Aceituno, Dai, and Rodriguez. IROS 2019 (To appear).

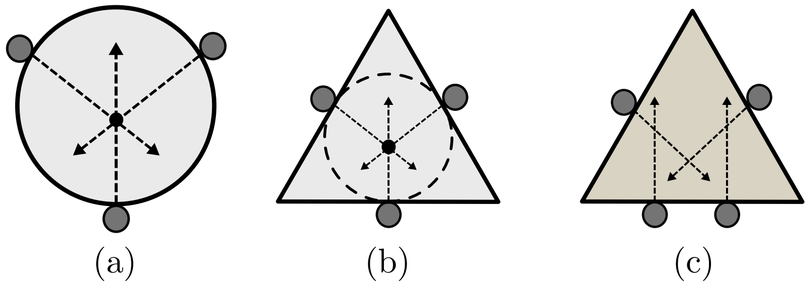
# Modeling

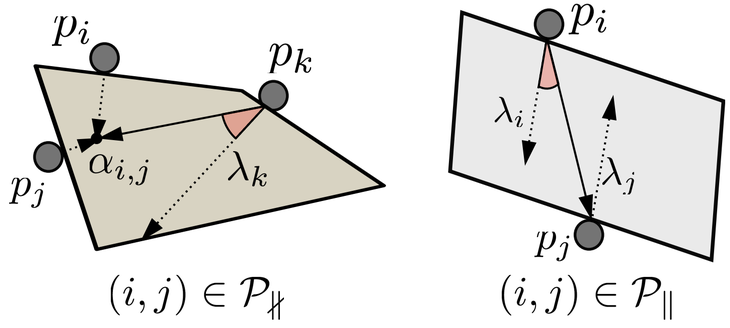



**Convergence**

- **Assumption:** Frictionless contact.
- Invariant set contracts gradually.
- Final set is a singleton.

# Modeling




- **Assumption**: proprioceptive sensing
- **Assumption**: no measure of curvature
- Satisfied with *First-Order Form Closure*.

**Observability**

# Application

*Finding a robust grasp that can certify success for pose uncertainty*

$$\textbf{MIQP1}: \min_{\mathcal{M}(t)} \int \sum_{i=1}^{N} \left\| \frac{d^2 \boldsymbol{p}_i(t)}{dt^2} \right\|^2 dt$$

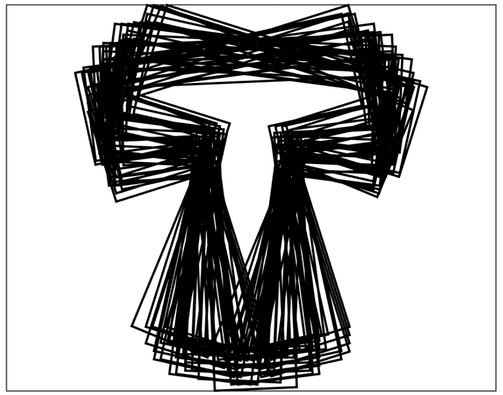
subject to:

1. For $t=1$ to $t=N_T$:
   - Caging (CT1)-(CT2).
   - Convergence Certificate (CT4)-(CT5).
2. ($t=1$) Invariance certificate (CT5).
3. ($t=N_T$) First-Order Grasp Observability (CT6)-(CT8).

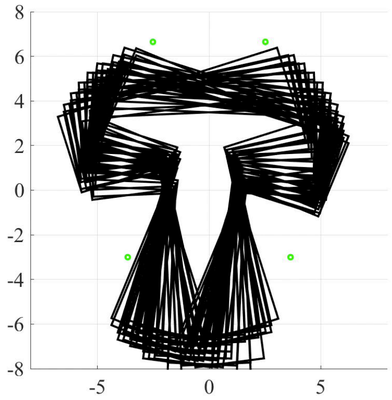
# Application

**Traditional Gr**

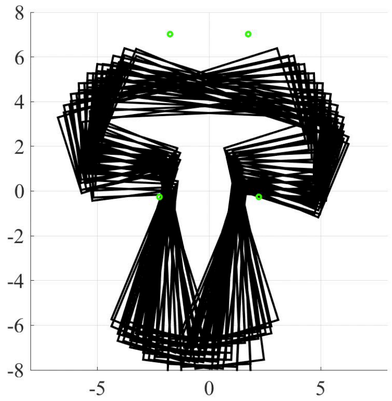
Initial Configurations



Naive Grasp with Force Closure



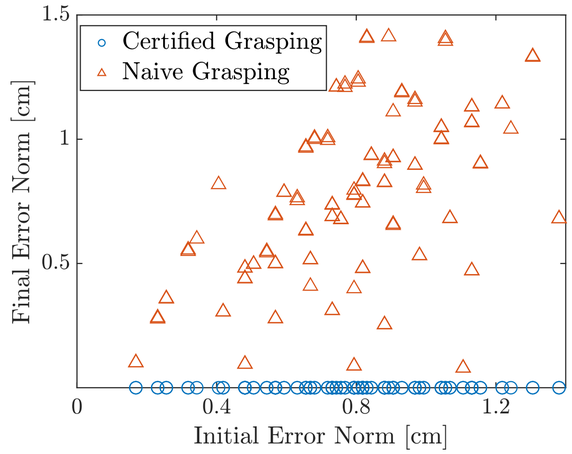

Certified Grasping



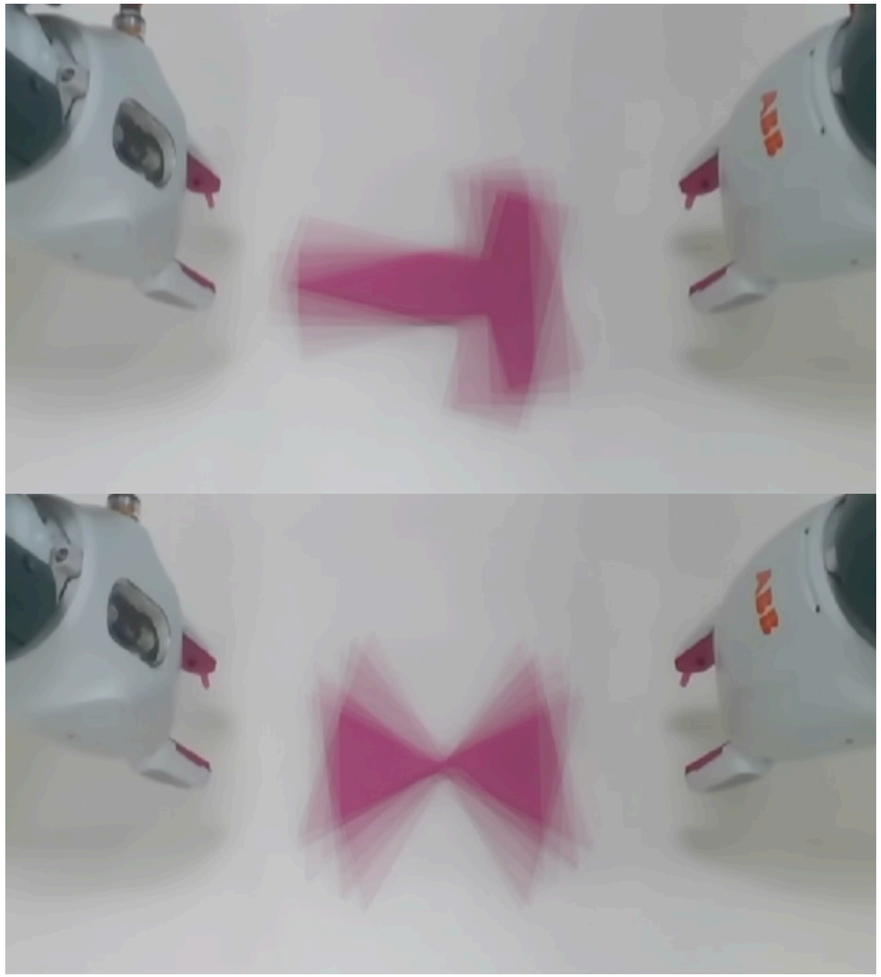

**ertified Grasping**

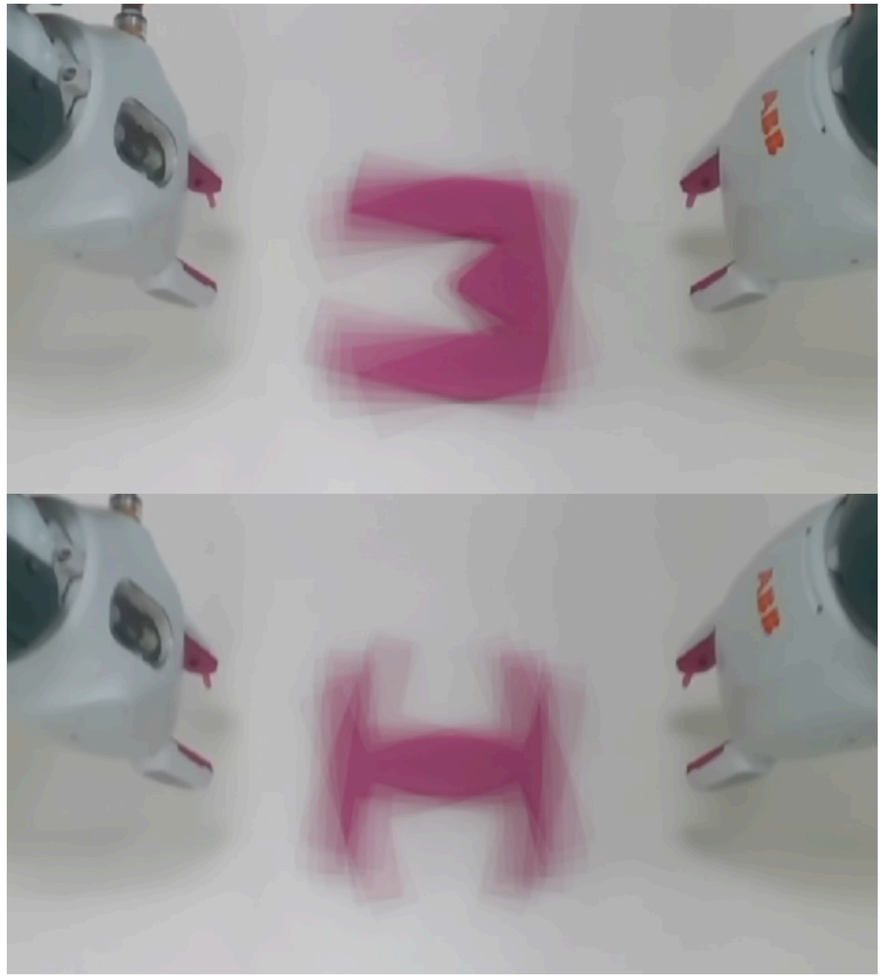
**pi**

**so**



# Application





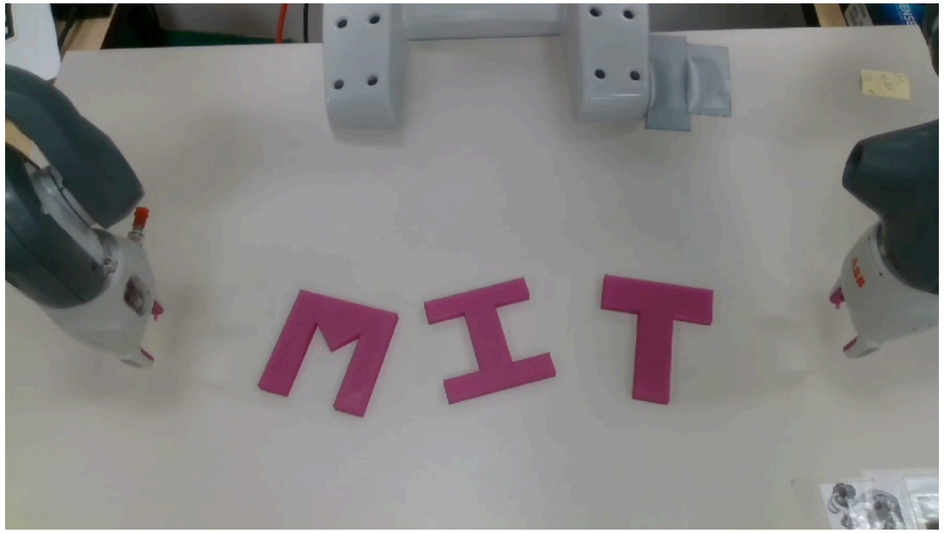
# Wrap-Up

**Contributions**

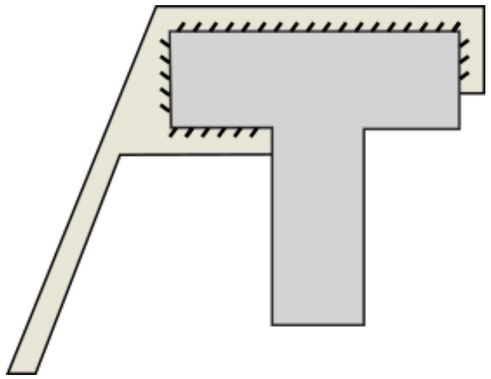
A model of certificates for grasping under pose uncertainty

**Limitations**

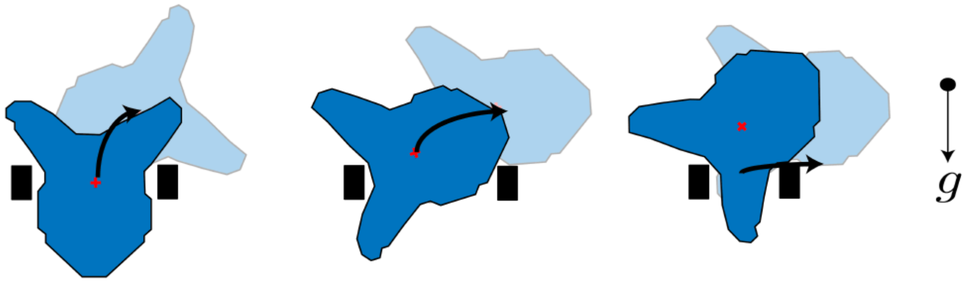
Not accounting for friction (jamming) nor curvature (observability).



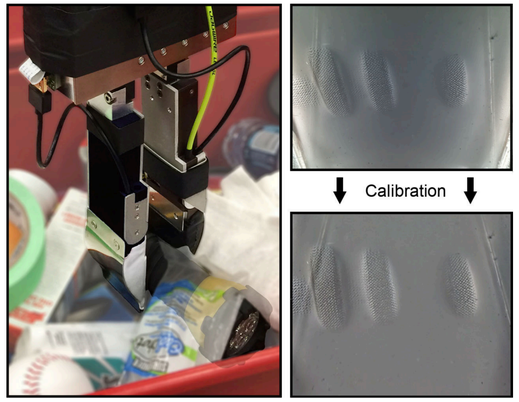
# Where to go next?



**Continuous geometry**




**Physics and external forces**




**More complex observability**

[Mahler'18][Donlon'18]

# Thanks!

*See you at interactive session!*