Using Vision for Pre- and Post-grasping Object Localization for Soft Hands†

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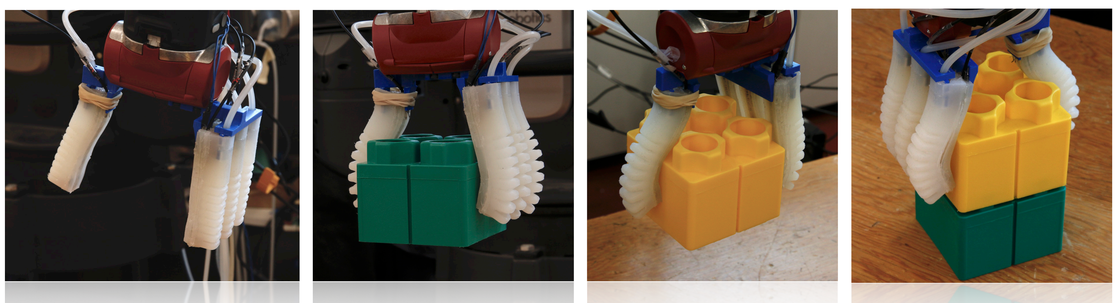
Motivation

Soft hands are **compliant** but increase **uncertainty** of object pose after grasping.

- How can we **reduce** the post-grasping uncertainty of object pose?
- How do we enable **soft hands** to perform **advanced manipulation** which requires precise object pose?

Introduction



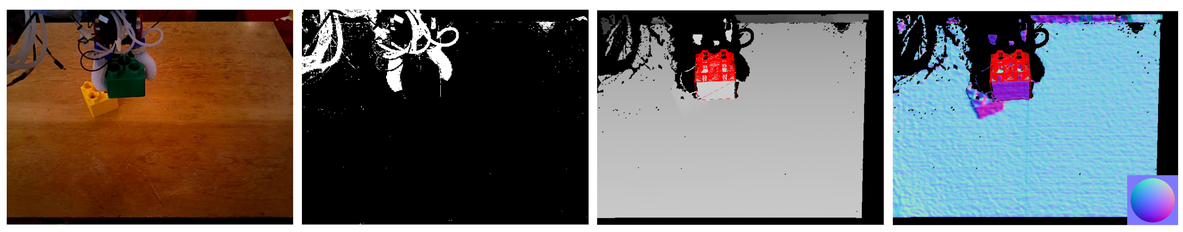
- Soft hands allow **compliance** and **adaptability**.
- They increase **uncertainty** of the object pose after grasping.

Visual sensing *ameliorates* the increased uncertainty!

In-hand Object Localization (IOL)

Goal: To estimate the 6-DOF **pose** of the object in the hand

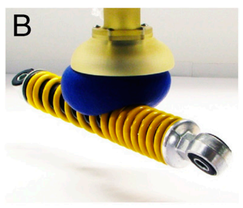
Occlusions by fingers!



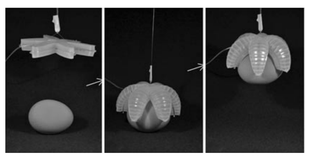
RGB | Hand detection | Depth | Normal

- The hand regions are estimated from a **Gaussian naive Bayes classification** (**H** & **S**).
- The detected finger regions are then *ignored* in the **depth-based object localization**.

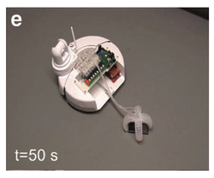
Related Work



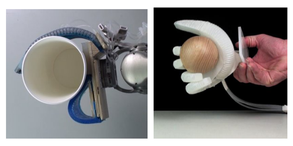
Jamming Gripper
Brown et al., PNAS'10



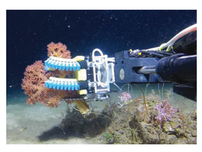
Starfish-shaped Gripper
Ilievski et al., Angewandte Chemie'11



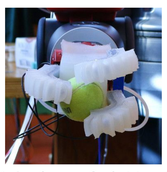
Quadruped Gripper
Stokes et al., SoRo'14



Multi-finger Soft Hands
Deimel & Brock, ICRA'13 & IJRR'16



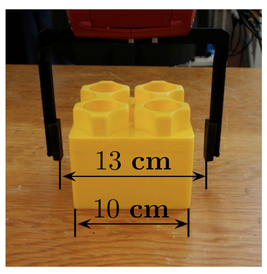
Multi-finger Soft Hands
Galloway et al., SoRo'16

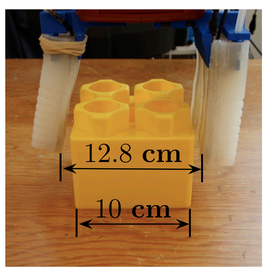


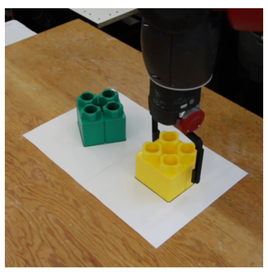
Multi-finger Soft Hands
Homberg et al., IROS'15

- Closing loop between *soft manipulation* and *visual perception* has been **less** addressed.
- We employ an RGB-D vision to go **beyond simple grasping** and to enable soft hands to do **advanced object manipulation**.

Evaluation

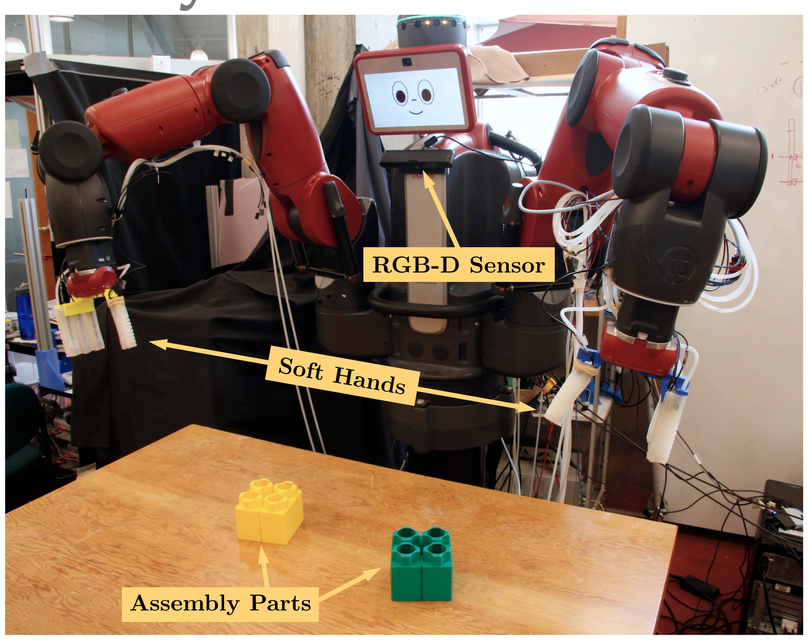




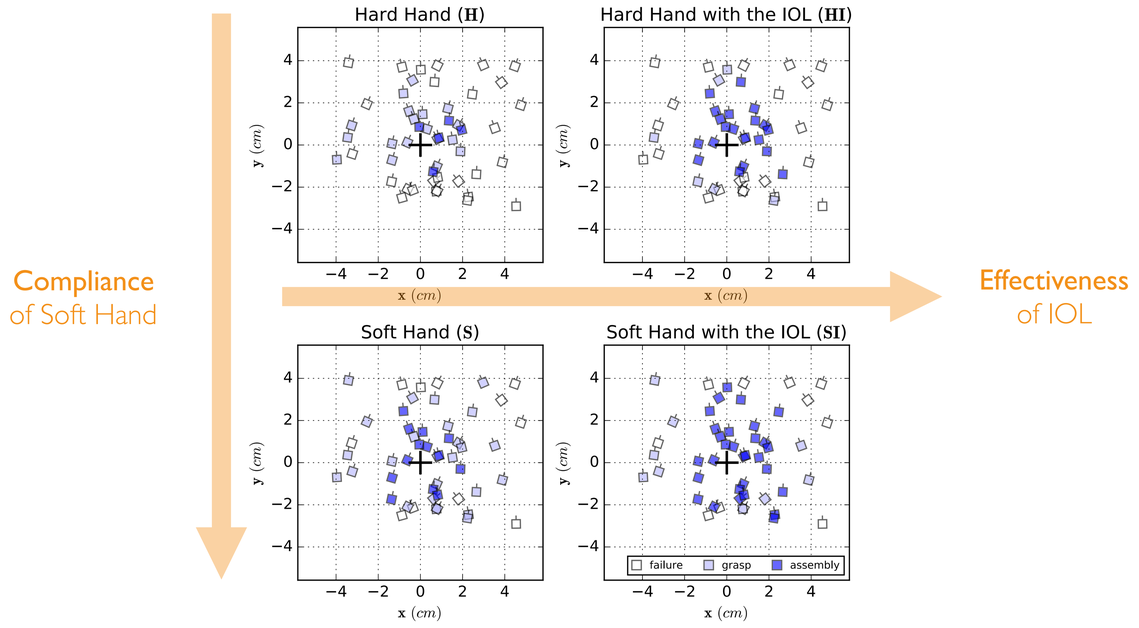


- Compare **hard** and **soft** hands
- **With** and **without** the IOL
- 4 configurations: **H**, **HI**, **S**, **SI**
- Fixed the locations of the blocks on the table
- 50 trials with Gaussian noise in object pose estimates

System Overview

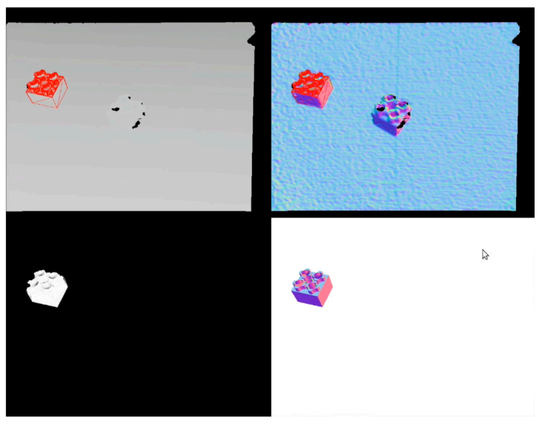


Evaluation: Fixed + Noise



Pre-grasping Object Localization

Goal: To estimate the 6-DOF **pose** of each object on a table



- Planar segmentation (table-top assumption)
- For each foreground object point cloud
  - center location $\mathbf{t} \in \mathbb{R}^3$
  - a set of rotations (in-plane) $\mathbf{R}_i \in \mathcal{R} \subset SO(3)$
- An ICP algorithm is initialized
- The maximum likelihood pose is chosen for each object

Evaluation: Random locations

Table 2: Success rates for 100 trials of the complete system experiment.

Measure	Hard Hand		Soft Hand	
	¬IOL (**H**)	IOL (**HI**)	¬IOL (**S**)	IOL (**SI**)
Successful Assembly	41%	66%	72%	92%

Conclusions

- **Soft hands** + an RGB-D **object localization**
- **Grasping** known objects and **connecting** two objects
- Soft hands are more **robust** than hard hands w.r.t. uncertainty.
- **In-hand object localization** (**IOL**) enables soft hands to perform an **assembly** task **reliably**.

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