Integrated Modeling and Learning for Robust Grasping and Manipulation with Adaptive Hands

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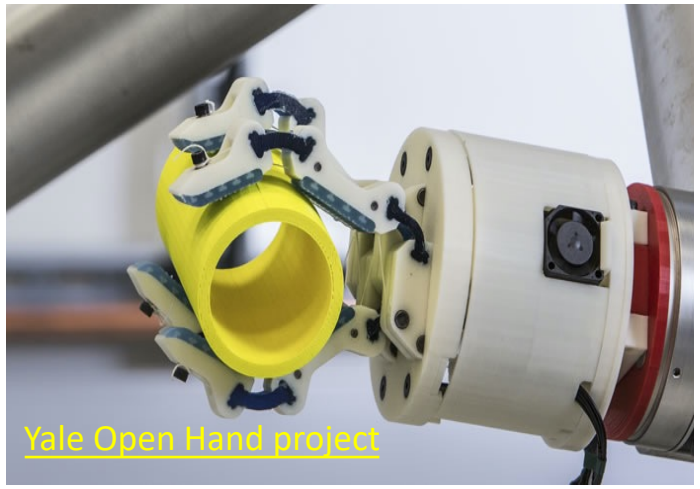
Promise of Adaptive Hands

- Passively adapt to objects
- Good grasping with limited sensing, control
- Low-cost, compact design

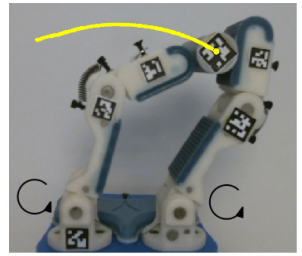
Challenges

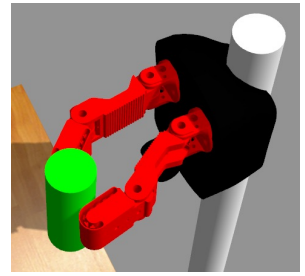
- Difficult to model
- Introduce uncertainty and inaccuracies in execution



Technical Approach

- Hybrid models based both on data and analytical tools that capture uncertainty and have reduced data requirements
- Tight integration with perception


Planned motion


Open-source Gazebo model

Impact

- Cross-disciplinary approach (mechanism, data, model and algorithms) for effective control given compliance, uncertainty
- Popularize and help adoption of such low-cost, open-source tools

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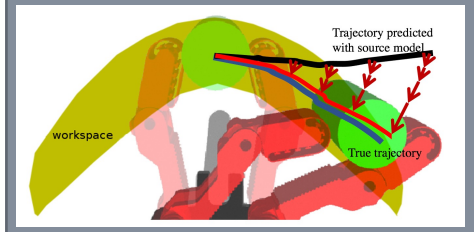
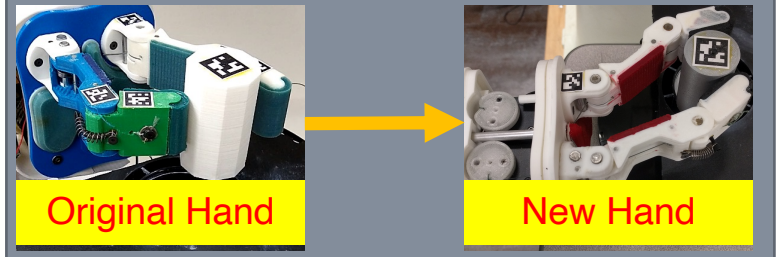
Highlights during 2020

Transfer Learning Across Different Hands

- Don't learn a new model for every new hand from scratch (12 hours of data)
- Record a small number of trajectories and transfer the original model.

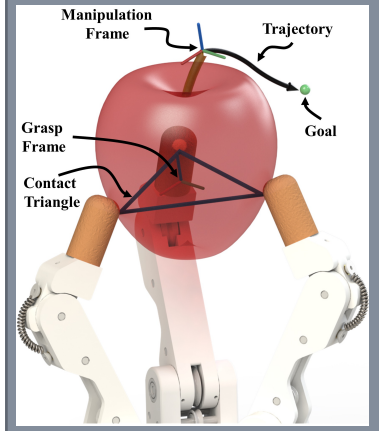


A cumulative residuals approach bounds the transfer errors



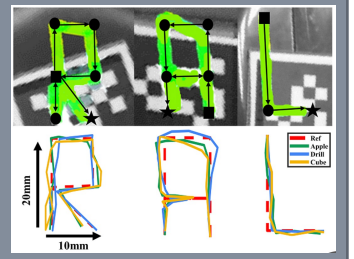
"Learning to transfer dynamic models of underactuated soft robotic hands", Schramm, Sintov, Boularias, ICRA 2020

MPC for Within-Hand Manipulation in Under-constrained SE(3)



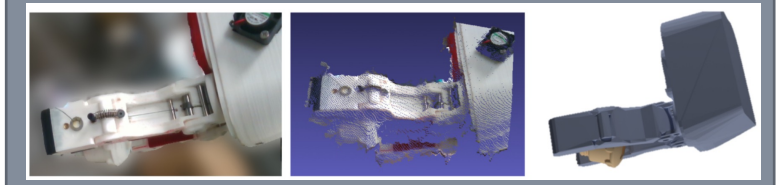
- Many tasks do not constrain all DoFs of the manipulated objects.
- For such tasks: developed object-agnostic models of the gripper via Model Predictive Control

Allows for simple vision-based control, such as writing RAL with different hand attachments



"Object-Agnostic Dexterous Manipulation of Partially Constrained Trajectories", Morgan, Hang, Dollar, IEEE RAL 2020

High-fidelity Visual Tracking of Manipulated Objects without FK



We can reliably track the 6D pose of occluded, manipulated objects only from vision and by training only in simulation

"se(3)-TrackNet: Data-driven 6D Pose Tracking by Calibrating Image Residuals in Synthetic Domains", Wen, Mitash, Ren, Bekris, ICRA 2020