NRI: FND: Controllable Compliance: A New Robotic Arm for Contact-Rich Manipulation

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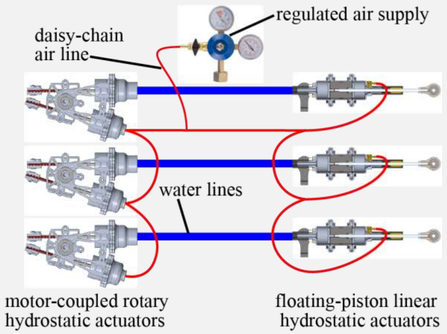
PI meeting video presentation: https://youtu.be/aJbnspOcWgs BGN: https://sites.google.com/view/bgn-pomdp/home

Challenges:

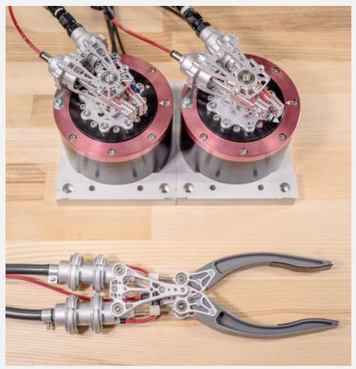
- Building a lightweight arm capable of active high-bandwidth impedance control is hard
- Controlling contact-rich interactions in uncertain environments is hard

Aims

- Developing a lightweight, low-impedence 7-DOF robot manipulator for research and mass production
- Employ ***remote direct drive*** (RDD) actuation concept
- Developing process for learning optimal controllers rather than tuning controllers for specific hardware

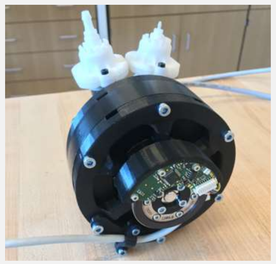


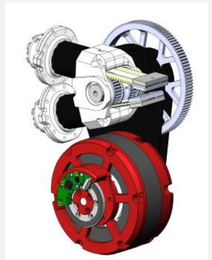
Low-friction hydrostatic transmission



2-DOF gripper, driven by remote direct-drive brushless motors

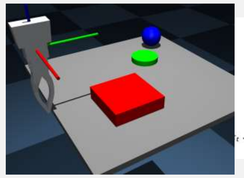
Under devel. 7-DOF arm, fully remotely actuated

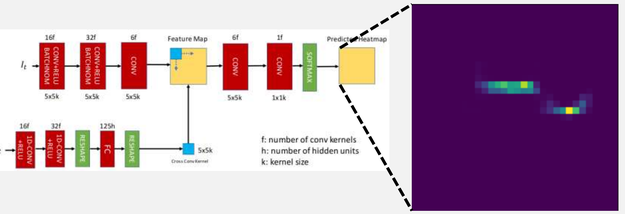




Brushless motor direct-drive and 3:1 coupling to hydraulic transmission rotary actuators

Localization and mapping using tactile information:



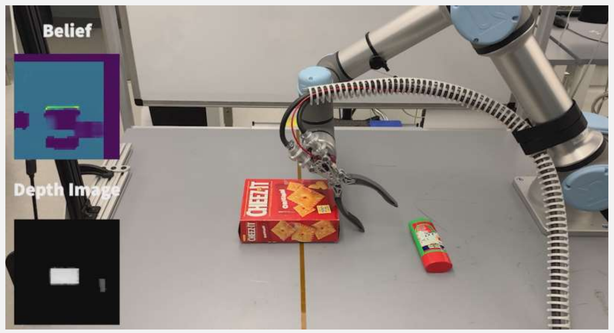


occupancy probability map

Problem:

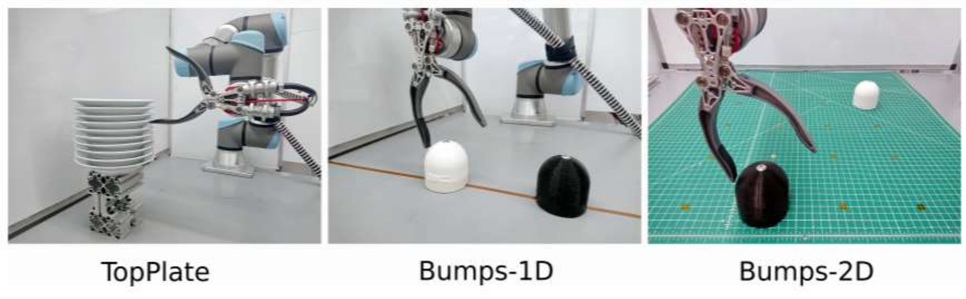
Map objects in a scene and localize robot finger using:

- Initial single coarse depth image
- Continuous finger force measurement



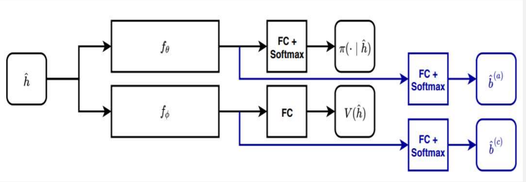
Testing on UR5e + 2-DOF RDD tactile gripper

Force-aware manipulation using Belief Grounded Networks (BGNs)



Manipulation tasks trained on force-feedback from low-impedance fingers

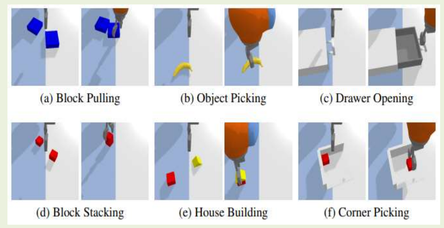
3 different tasks, all training offline



BGN combined with A2C. The belief state is reconstructed from partial observations during training. The resulting policy is history, not belief based, so we forego calculating belief state during runtime.

Ongoing Work:

- Online training via teleop demonstrations, leveraging SO(2) Equivariant SAC
- Extend to use the operator-controlled contact impedance in online training



Teleop setup with haptic glove