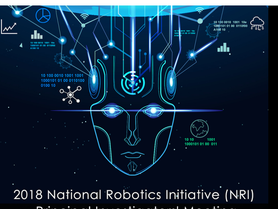


NRI: FND: Controllable Compliance: A New Robotic Arm for Contact-Rich Manipulation (award 1830425)

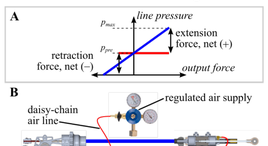
John Peter Whitney (PI) and Robert Platt (co-PI)

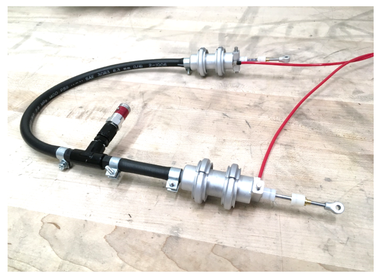
The Helping Hands Lab

robotics collaborative

Northeastern University

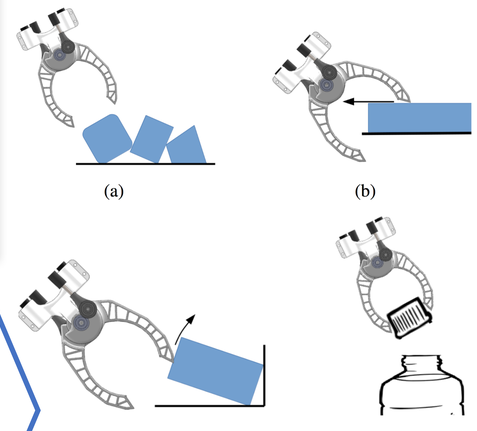
1:1 Hydrostatic Transmission



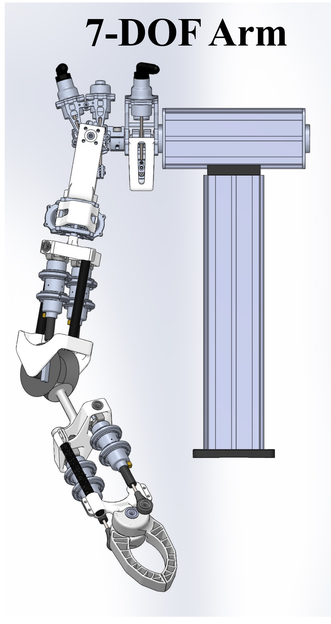


Traditional serial-chain robot arms and manipulators driven by electric motors require high gear ratios and sacrifice compliance and efficiency to reduce moving-mass to acceptable levels. This research uses low-friction hydrostatic transmissions to move all electric motors out of the arm, enabling remote-direct-drive actuation. The resulting system exhibits substantially ideal second-order dynamics, allowing easy modulation of the impedance at each joint, independently. This opens the door to effectively mixing contact forces and point-cloud data into deep RL methods to develop grasp controllers, where joint impedance is reduced in cases of high uncertainty, or when initiating purposeful contact with the environment to probe the environment via force interactions.

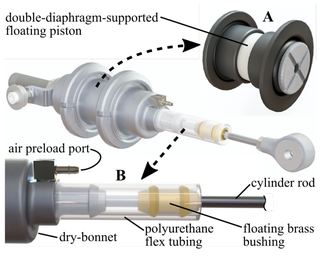
Grasp Behaviors

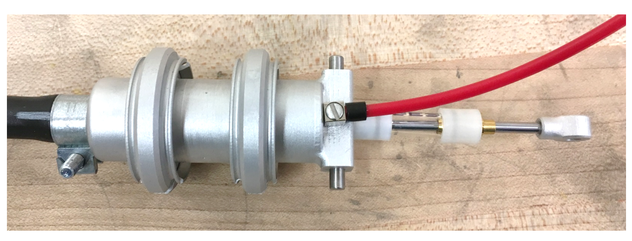


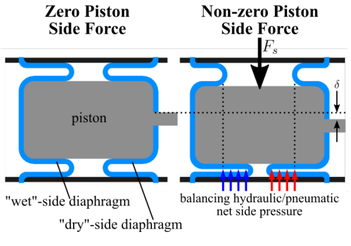
7-DOF Arm

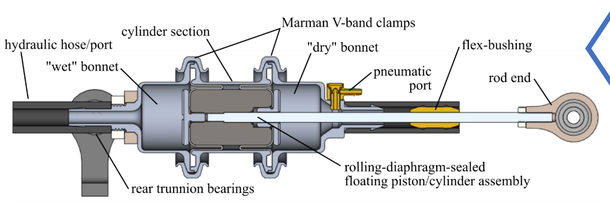


Fully-Floating-Piston Linear-Motion Hydrostatic Actuator







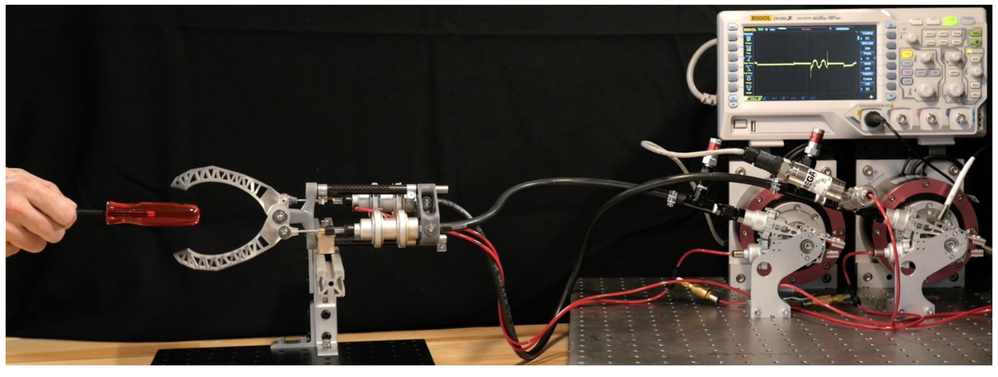


We are exploring control strategies that leverage our ability to tune joint impedance on-the-fly. We want to answer two important questions. First, from the perspective of control policy learning, how much does it help to use a manipulator that is not dominated by non-smooth frictional dynamics of standard actuators? Second, can we use the dynamic properties of the arm to make manipulation policies more robust to environmental uncertainty, for example by increasing compliance to accommodate environmental uncertainty but stiffening at other times? Applying force as well as point-cloud data to grasping policies via deep RL can help strike this balance.

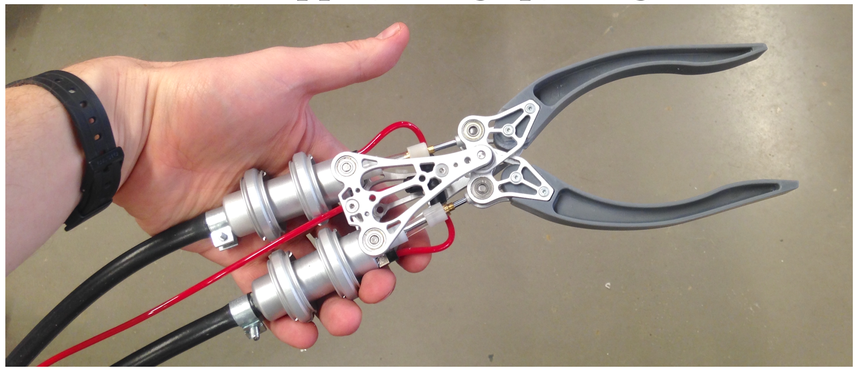
The linear actuator achieves bidirectional motion through the use of a floating piston comprised of antagonistic rolling diaphragm seals. The only friction in the actuator is due to fluid viscosity and seal hysteresis. The rod seal is a non-contact, continuously-leaking air-bearing seal.

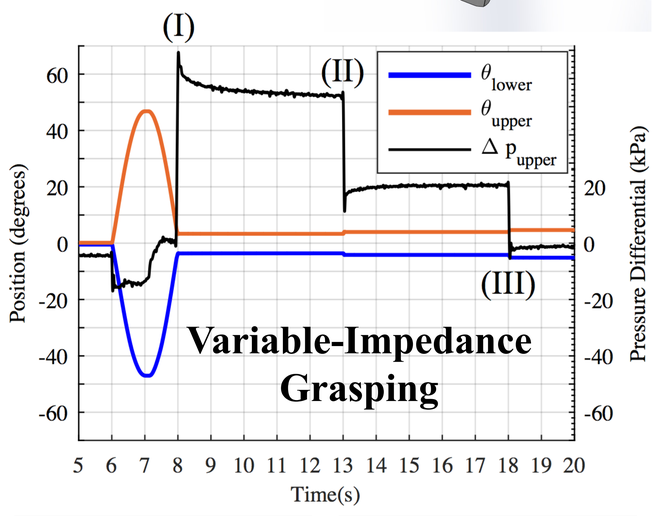
The gripper is a 2-DOF end effector, using two linear actuators to achieve grip opening and wrist articulation.

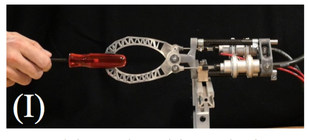
Remote-Direct-Drive Configuration



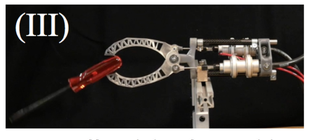
2DOF Gripper, 50N grip, 220 grams







screwdriver placed into closing fingers, high PD gains



motors off, weight of screwdriver backdrives motors and falls

NSF