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

Award Number: 1830425

Peter Whitney and Rob Platt

NRI 2021 PI Meeting

robotics collaborative

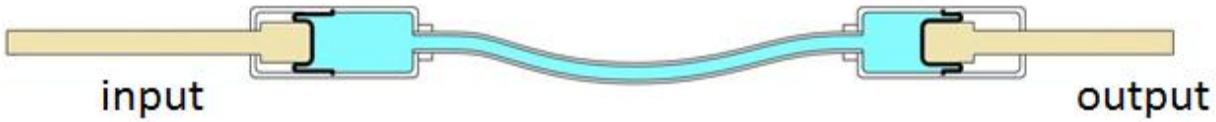
The Helping Hands Lab

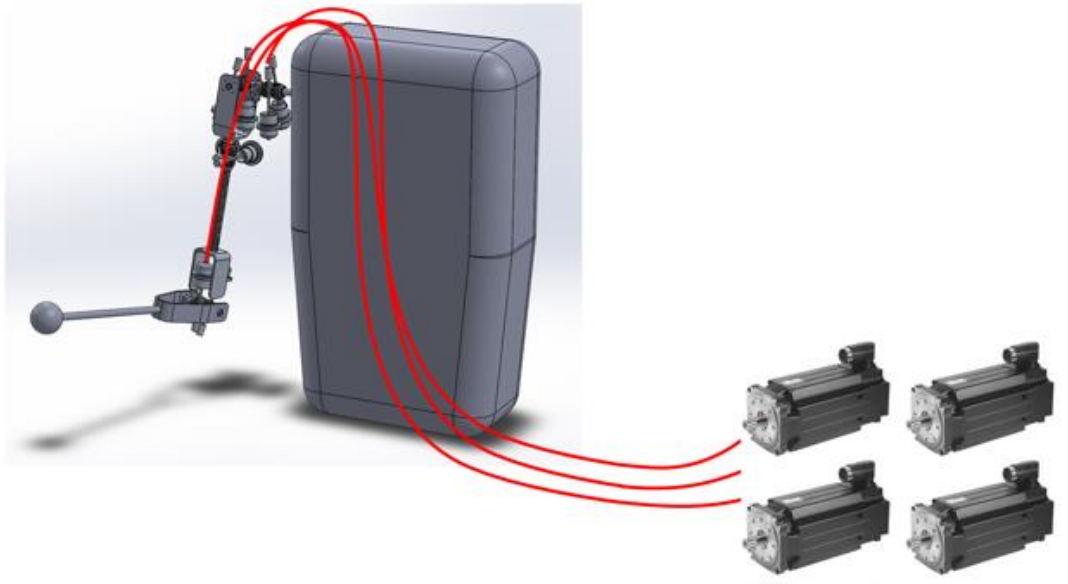
Northeastern University

Remote Direct Drive (RDD) Actuation

- **Low-friction hydrostatic transmission allows ALL motors in arm to be remotely located—*extremely low moving mass***
- **Initial experimental configuration uses a 2-DOF RDD gripper, pending completion of 7-DOF RDD arm**
- **Fluid pressure measurement allows precise measurement of endpoint contact forces**

rolling diaphragm hydrostatic transmission

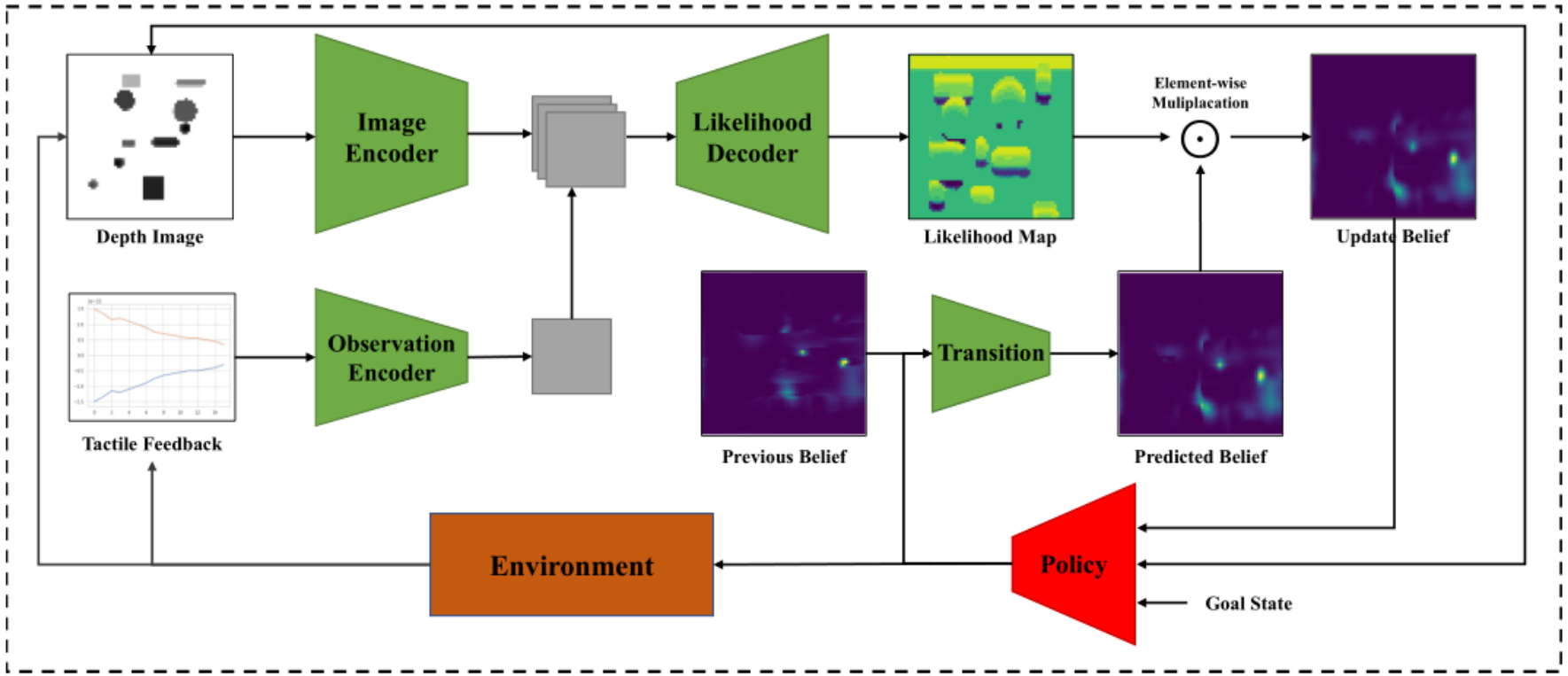




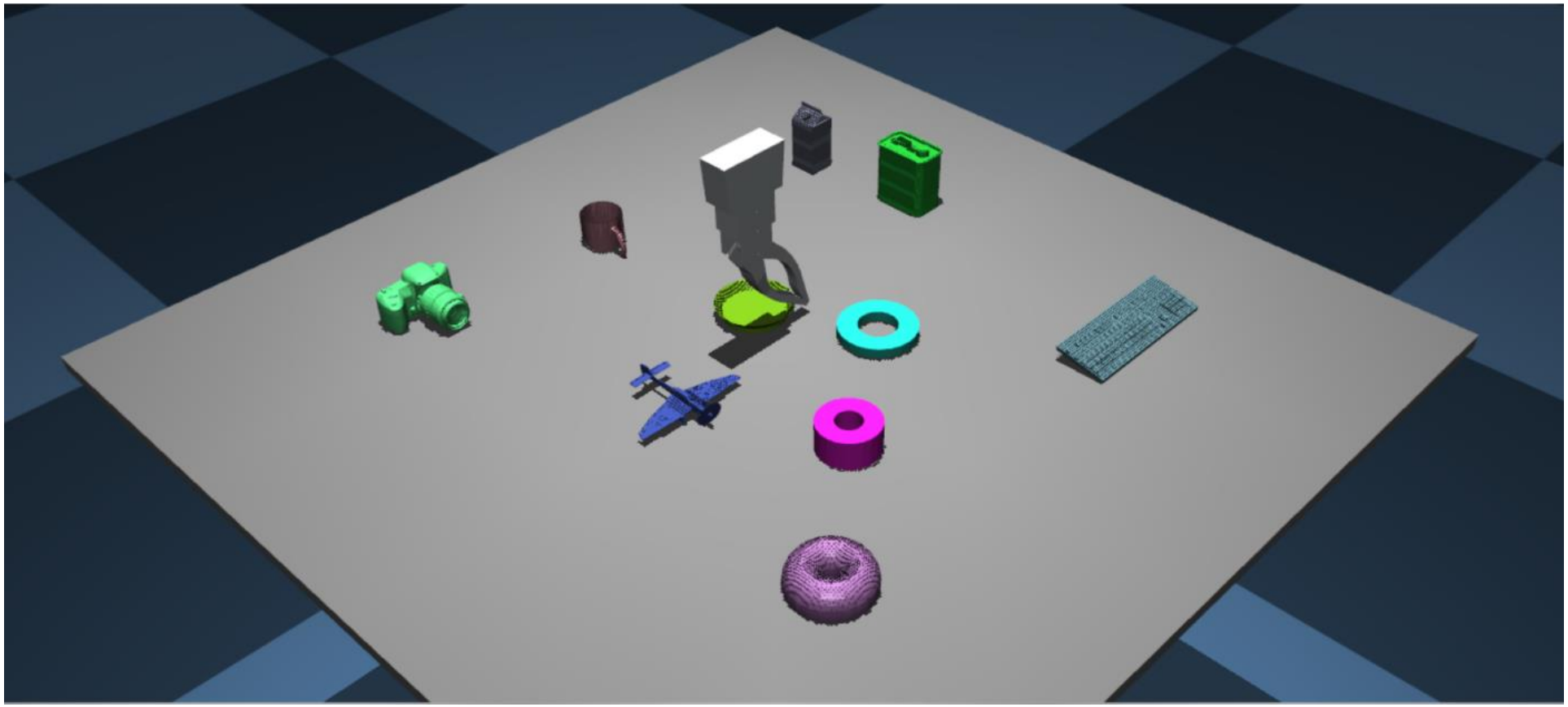
2-DOF gripper

Tactile Localization

- **Differential Bayes filter + deep RL**
- **Fuses single depth image with continuous tactile force feedback**
- **System modeled as MOMDP**

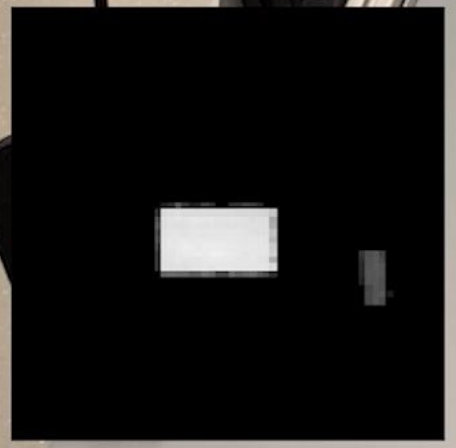


Tactile Localization



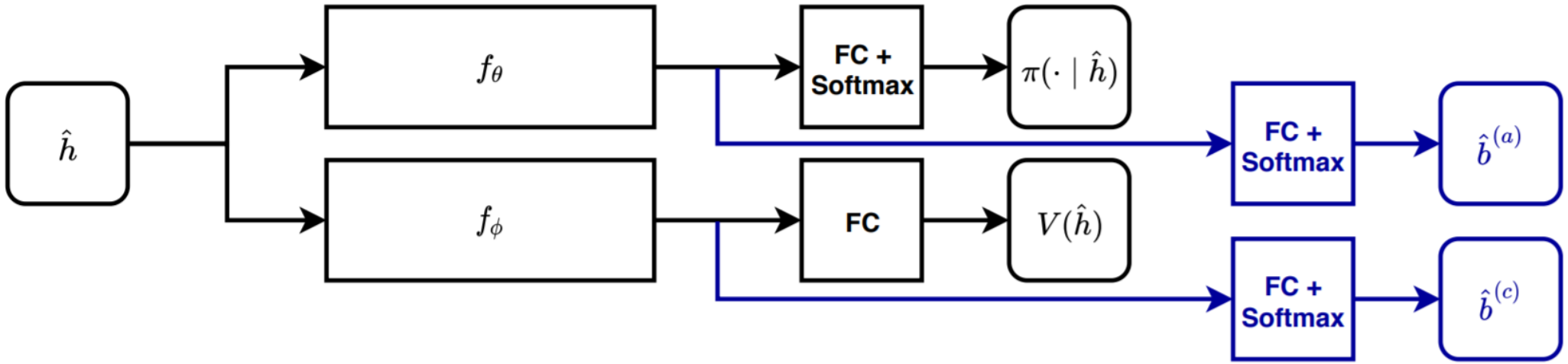
Belief

Depth Image

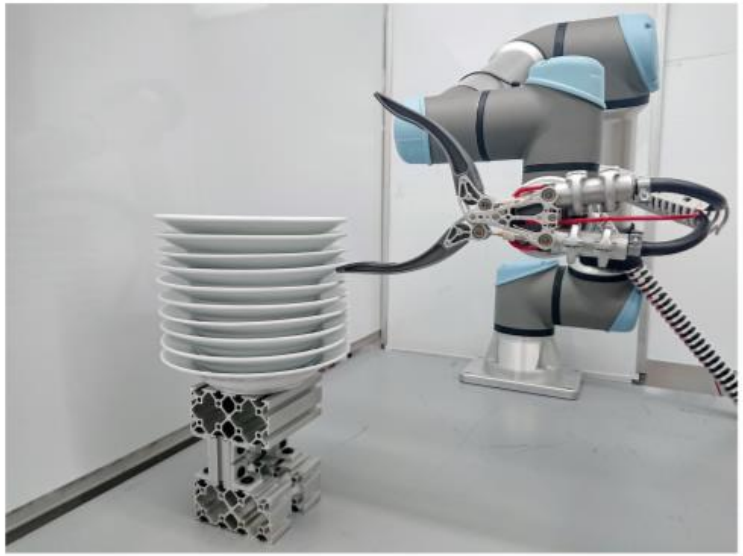


Belief Grounded Network (BGN)

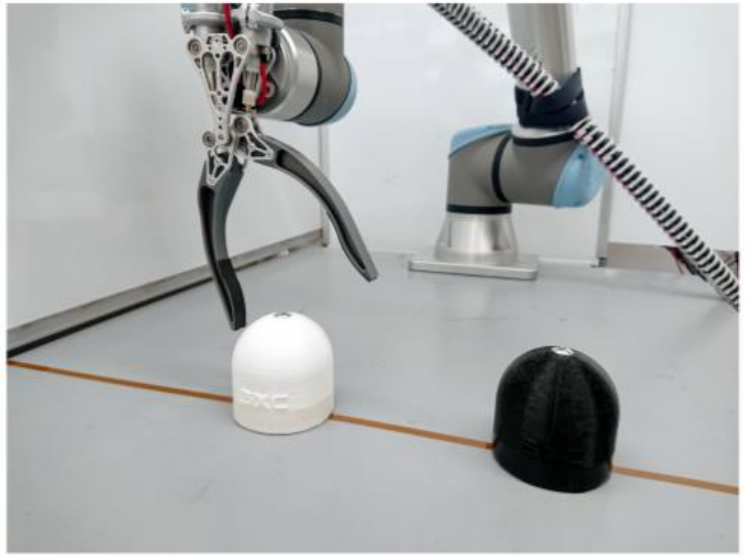
- **We introduce a new model called the Belief Grounded Network (BGN) where we add a belief-reconstruction loss to a deep reinforcement learning agent during simulated training.**
  - **Sync Advantage Actor Critic (A2C) + history summaries**
  - **MuJoCo training environment**



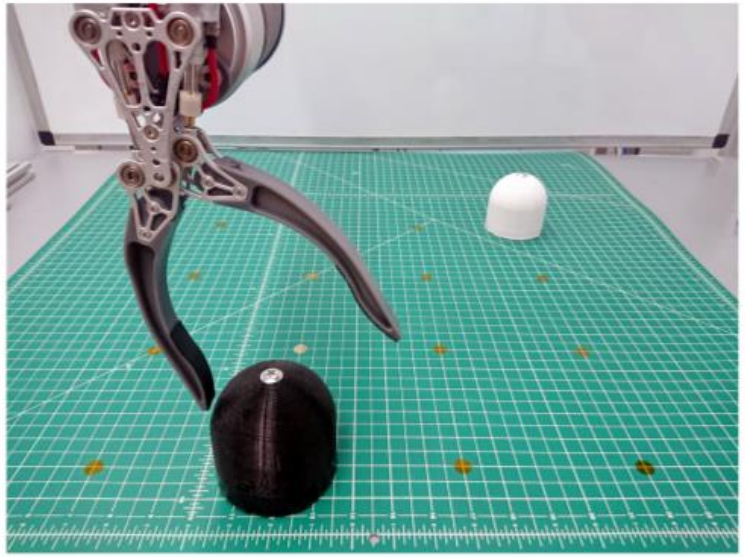
Belief Grounded Network (BGN)



TopPlate

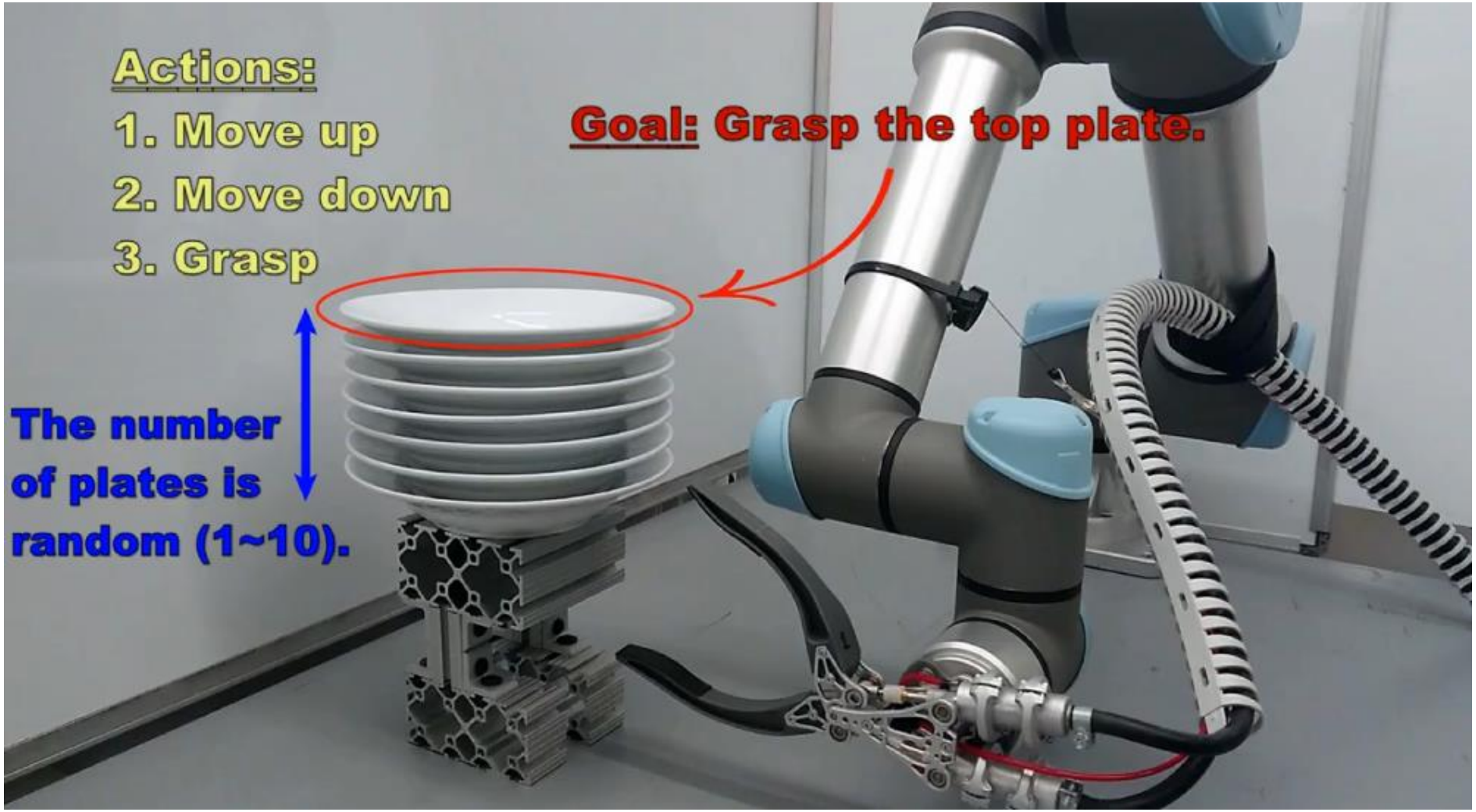


Bumps-1D



Bumps-2D

TopPlate (BGN)



TopPlate (BGN)

Belief Grounded Network

Belief-Grounded Networks for Accelerated Robot Learning Under Partial Observability

Conference on Robot Learning (November, 2020)

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Ongoing Work

- Robot platform
  - Transitioning to 7-DOF arm with fully remote-direct-drive (RDD) actuation and force sensing
- Learning
  - Online adaptation of stiffness for complex and coordinated tasks (e.g. grasping delicate objects in sand)
  - Integrating reflex behaviors into grasp controllers