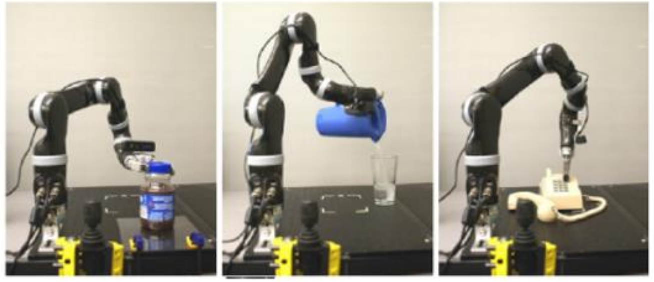
Learning Deep Sensorimotor Policies for Shared Autonomy

Presented by: **Siddharth Reddy**, UC Berkeley
PI: **Sergey Levine**, UC Berkeley
Co-PI: **Siddhartha Srinivasa**, University of Washington

Deep shared autonomy vision



assistive control for tasks of daily living

Basic challenges

- **Intent:** robot must understand what the person is trying to do
- **Assistance:** robot must offer assistance in a way that is natural and maintains human control
- **Perception:** robot must be able to perceive objects in the world from its on-board sensors

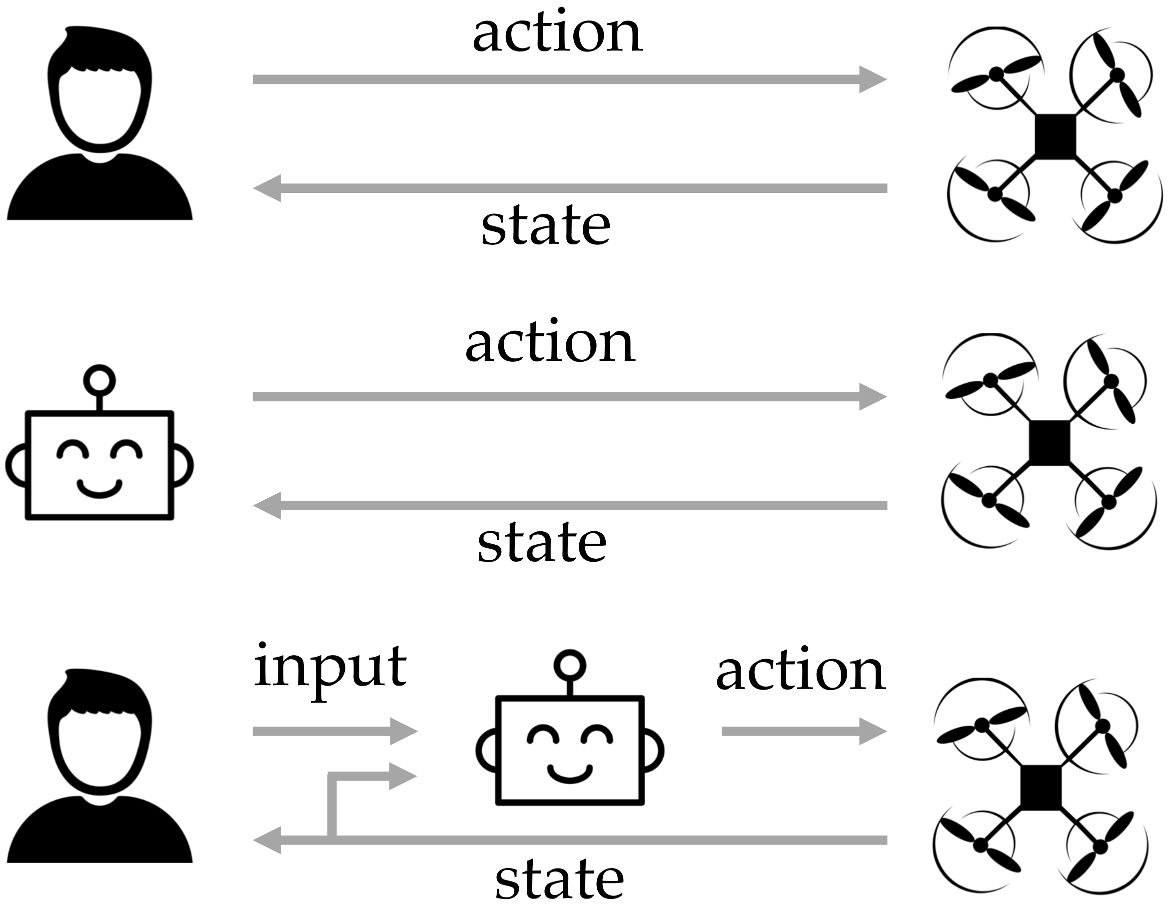
Algorithmic foundations

- Algorithms for **inverse reinforcement learning:** inferring the goals of the human from observing their behavior
- **Imitation learning:** learning how to perform a task from observing human behavior, even when it differs in terms of embodiment or capability
- **Shared autonomy:** learning how to perform a task **together** with a person

Experimental evaluation

- **Robot-assisted feeding**

Augmenting human control with deep Q-learning



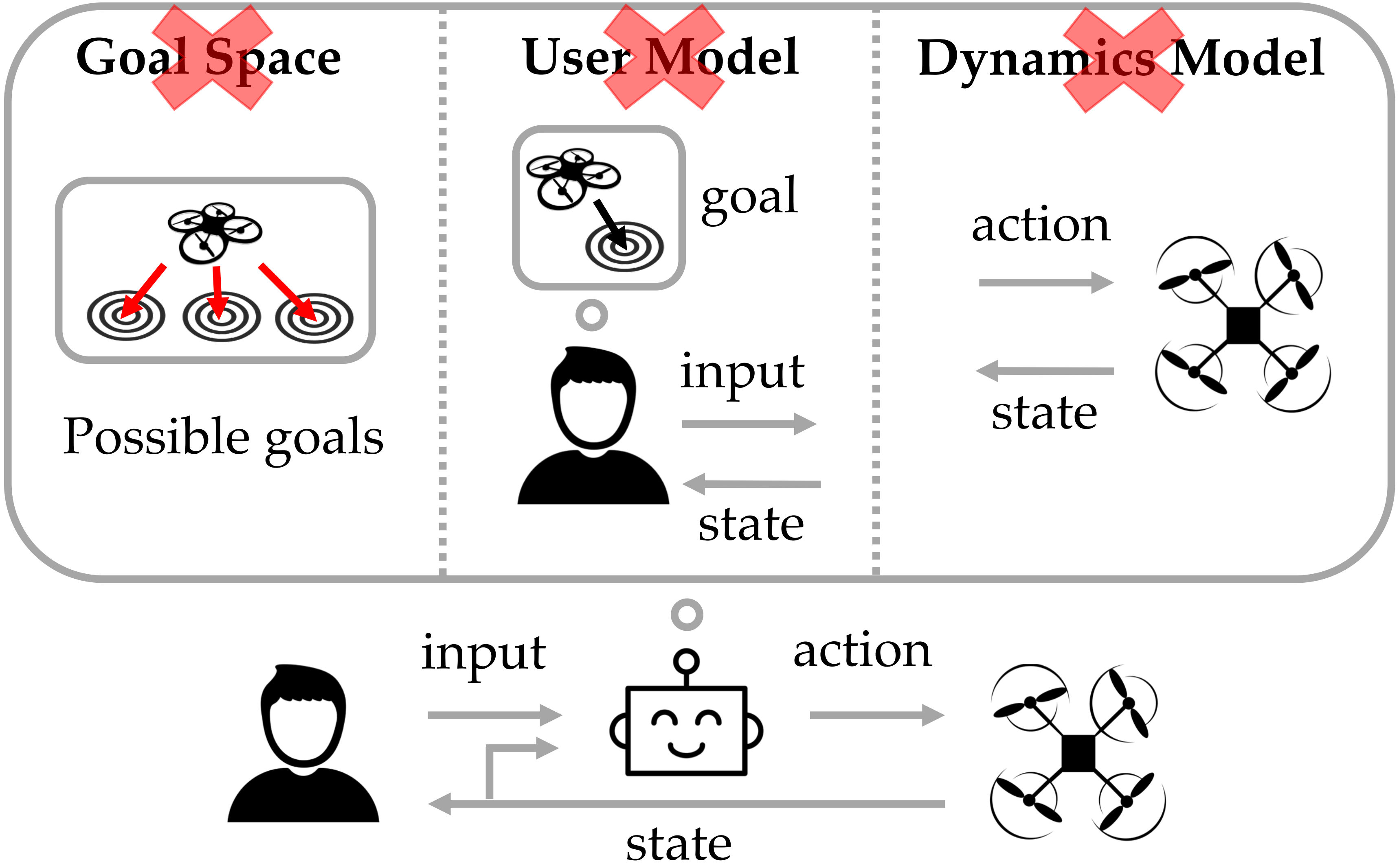
Solo Human Pilot
Knows intent, suboptimal ability

Autonomous Robotic Pilot
Doesn't know intent, near-optimal ability

Shared Autonomy:
Human Pilot + Robotic Copilot
Knows intent, near-optimal ability

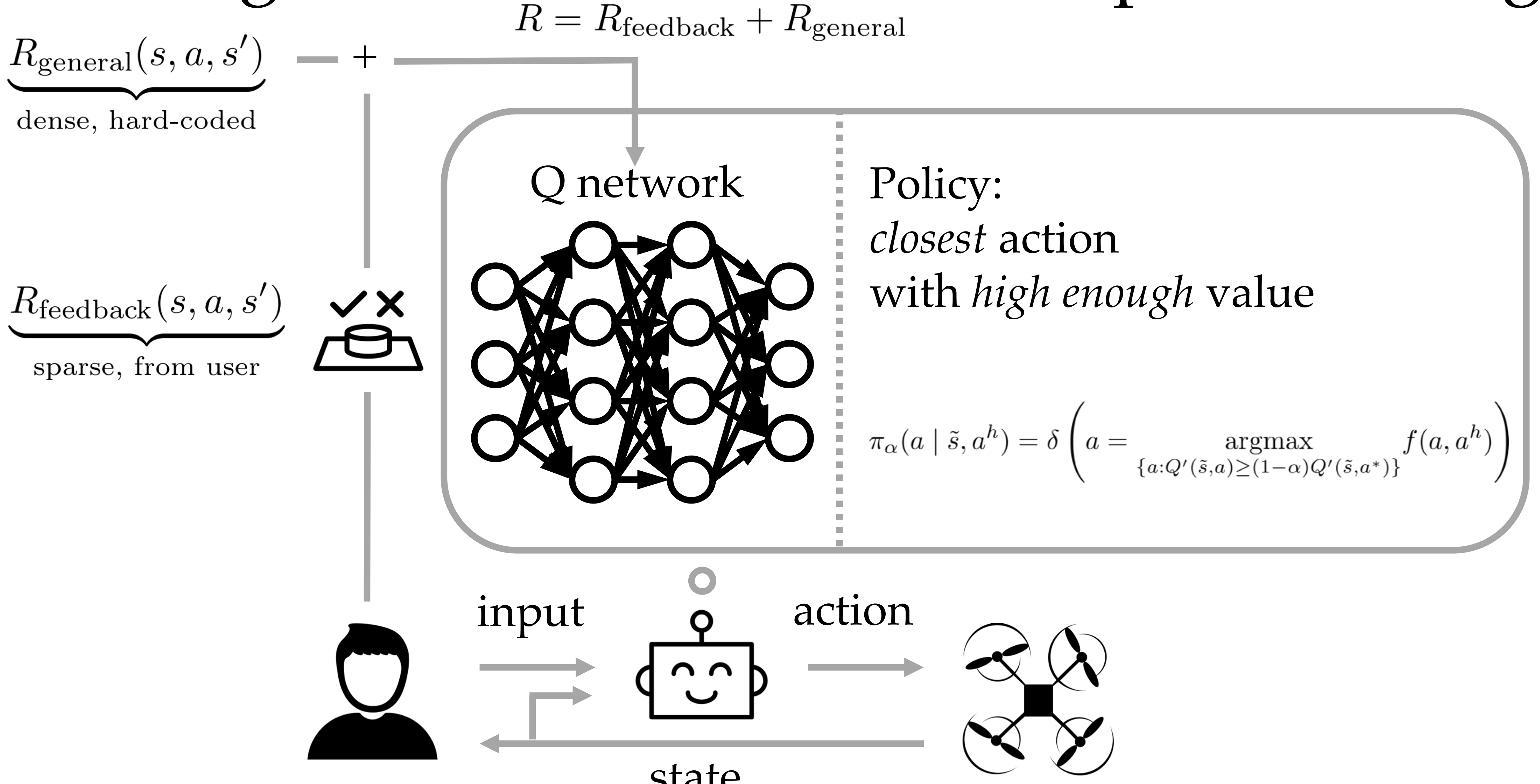
Shared Autonomy via Deep Reinforcement Learning
Siddharth Reddy, Anca D. Dragan, Sergey Levine

Augmenting human control with deep Q-learning



Shared Autonomy via Deep Reinforcement Learning
Siddharth Reddy, Anca D. Dragan, Sergey Levine

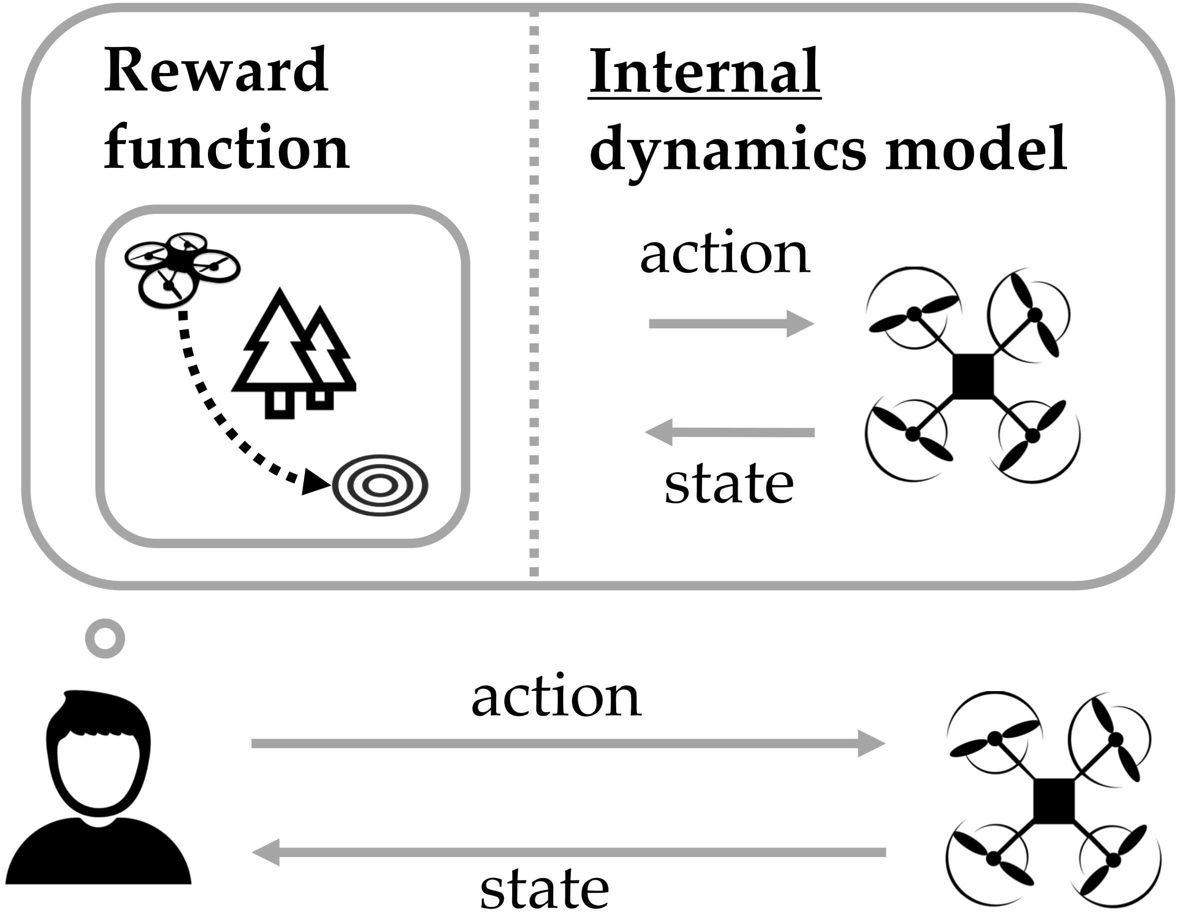
Augmenting human control with deep Q-learning



Shared Autonomy via Deep Reinforcement Learning

Siddharth Reddy, Anca D. Dragan, Sergey Levine

Inferring beliefs about dynamics from behavior



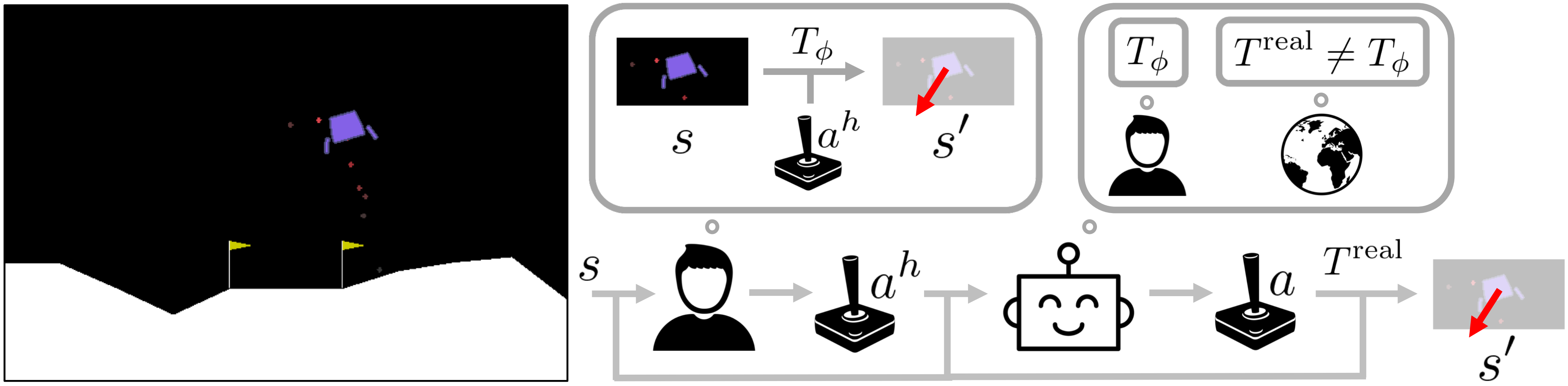
Where Do You Think You're Going?: Inferring Beliefs about Dynamics from Behavior
Siddharth Reddy, Anca D. Dragan, Sergey Levine

Inferring beliefs about dynamics from behavior

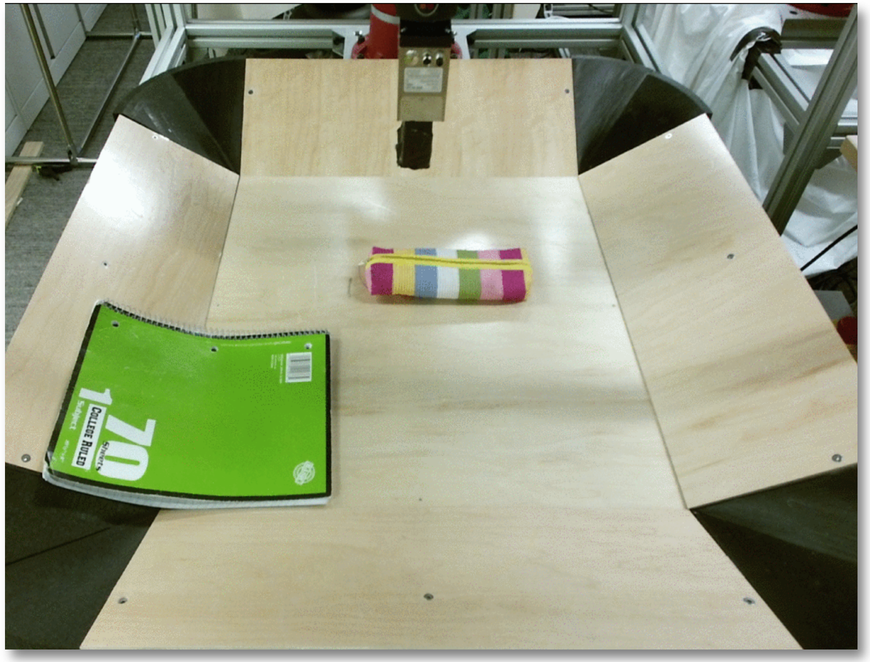
- Training time: **learning from demonstrations**

Demonstrations —— Our learning algorithm ——> Demonstrator's internal dynamics model

- Test time: **shared autonomy via internal-to-real dynamics transfer**

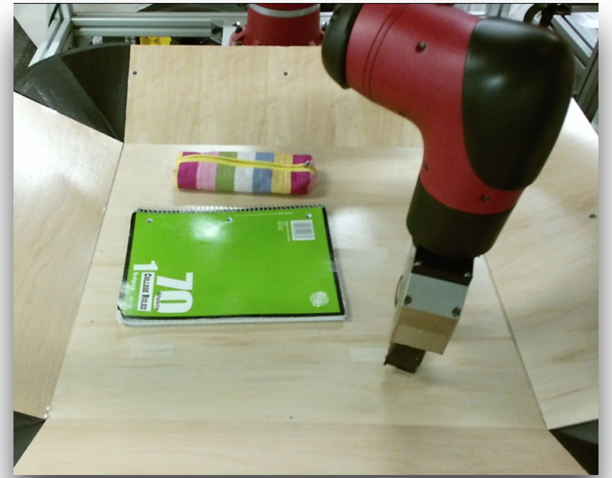


Where Do You Think You're Going?: Inferring Beliefs about Dynamics from Behavior
Siddharth Reddy, Anca D. Dragan, Sergey Levine



“what” & “how”

Do we need the entire demonstration to infer the goal?

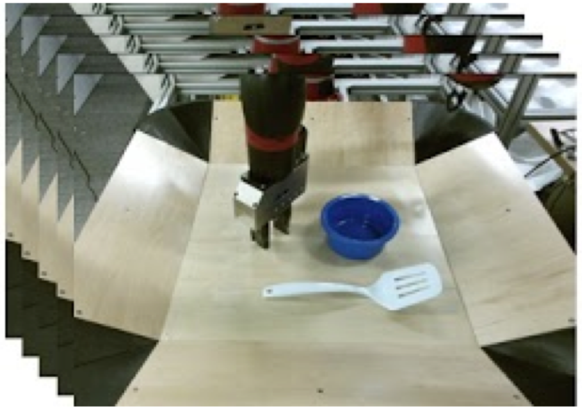


“what”

Xie, Singh, Levine, Finn ‘18

using the classifier as
reward for control

given 5 examples of
success



Xie, Singh, Levine, Finn '18

demonstration

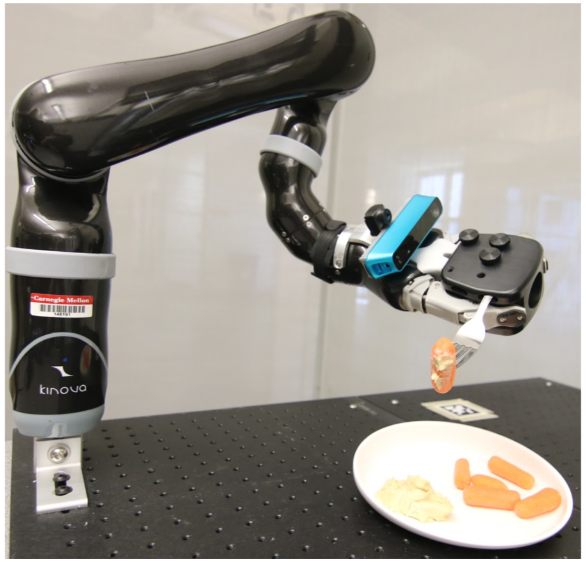
testing

Robot-assisted feeding

High-level goal: Enabling an assistive robot to feed a person with upper extremity disabilities

High-impact task:
- An activity of daily living (ADL)
- 56.7 million people had disability (Brault, 2012)
- 12.3 million people needed assistance with ADLs (Perry, 2008)

Problem decomposition:
- **Bite acquisition**: food perception, manipulating deformable objects
- **Timing for bite transfer**: understanding the cadence of social dining



bite acquisition

bite transfer

Robot-Assisted Feeding

The robotic system uses **multimodal sensing** to acquire food and transfer it using different food **item-dependent manipulation primitives**

Timing for bite transfer

- Features such as **gaze direction (speaker or plate), conversation, mouth (closed or open), and time since last bite** are informative of bite timing

- Represented as a state-transition model
  - **More states than bite acquisition and eating**, e.g., people waiting with full fork vs. empty fork

Learning Deep Sensorimotor Policies for Shared Autonomy

Presented by: **Siddharth Reddy**, UC Berkeley
PI: **Sergey Levine**, UC Berkeley
Co-PI: **Siddhartha Srinivasa**, University of Washington