

November 18th, 2025
ELLIIT - Focus Period on Robot Learning

Robot Learning Through Interactions

Jens Kober



Interactions with Teachers



Unsplash
Rinke Dohmen



liveabout.com

Teaching Through Interactions

- Continued student-teacher interaction
 - Additional demonstrations
 - Intermittent feedback
- More & more in robot learning
- Benefits
 - Speed-up
 - Complex tasks
 - Intuitive



Not Only Humans...

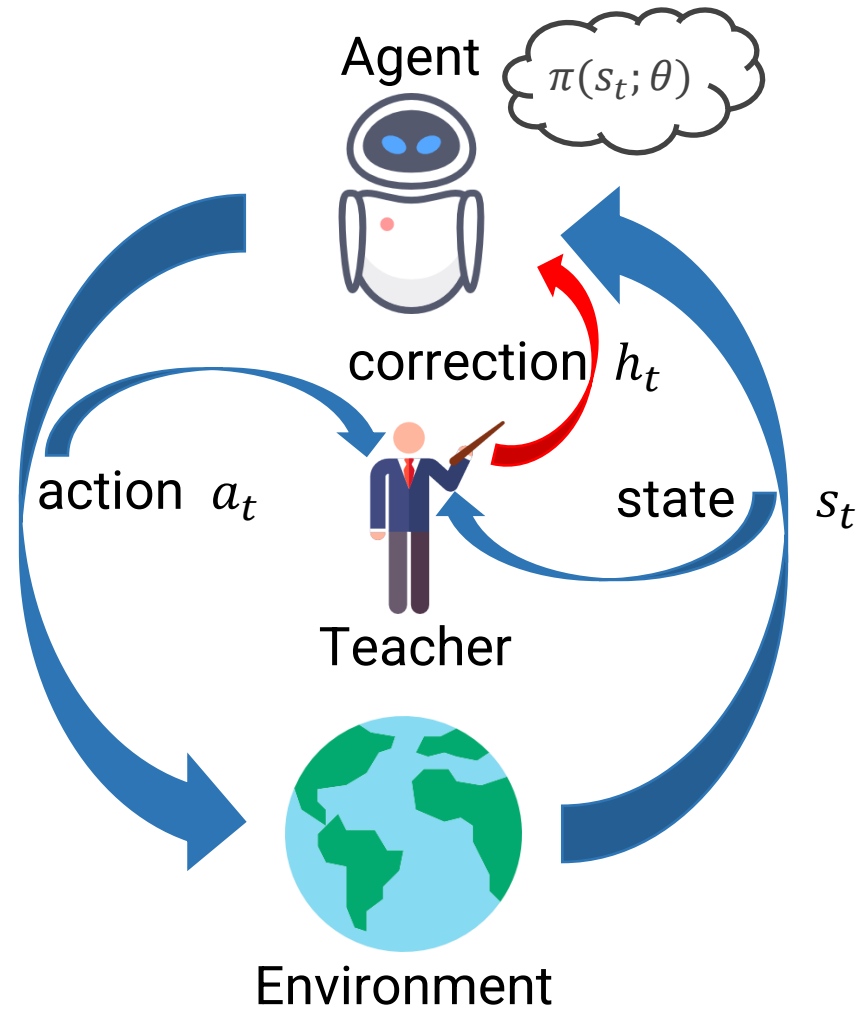


Unsplash
Petr Magera



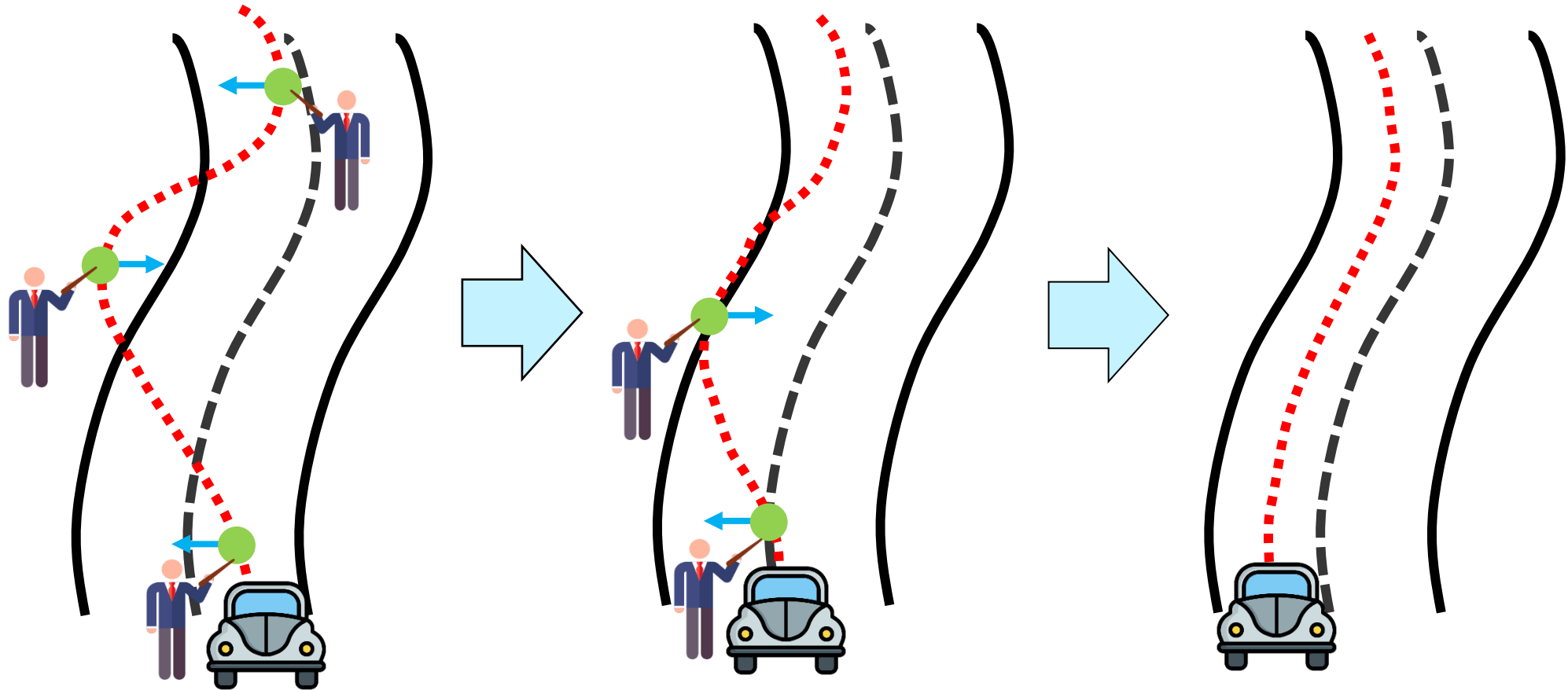
CC BY-SA
Rama

Interactive Learning

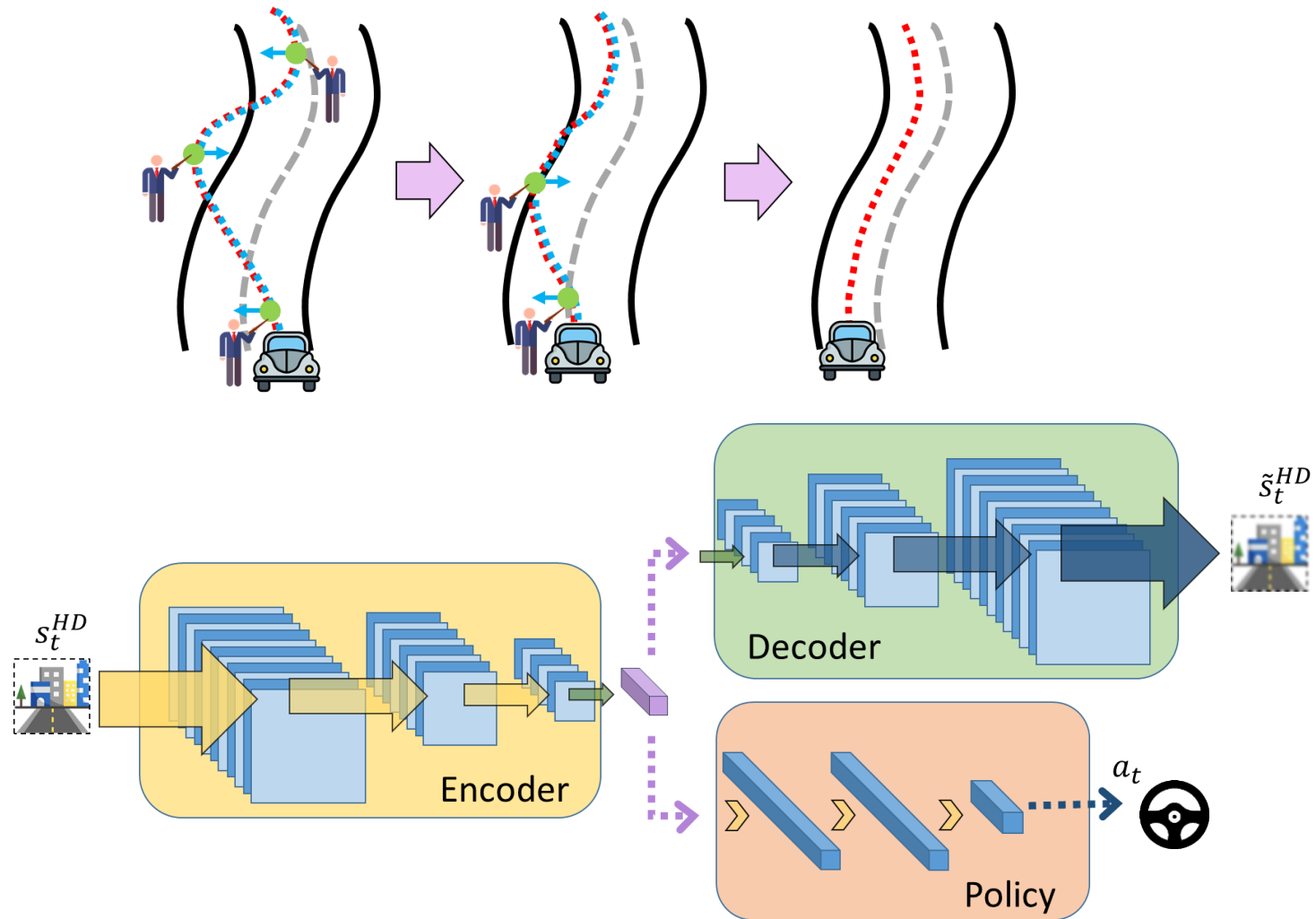


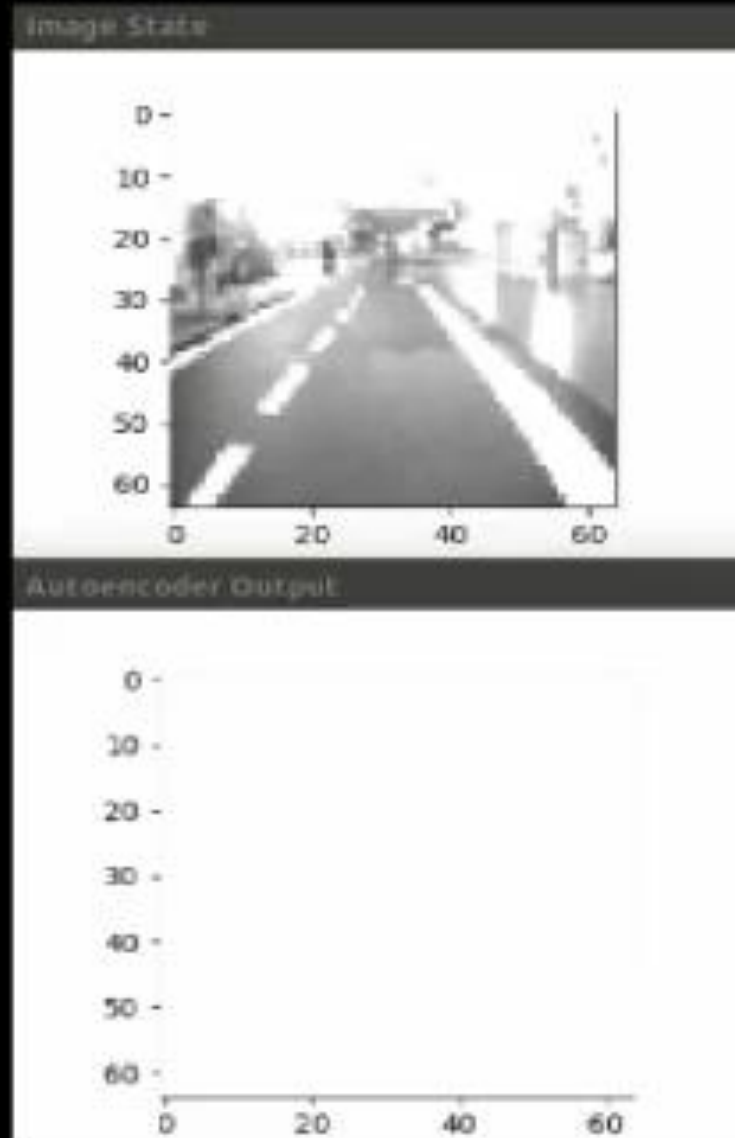
Interactive Imitation Learning

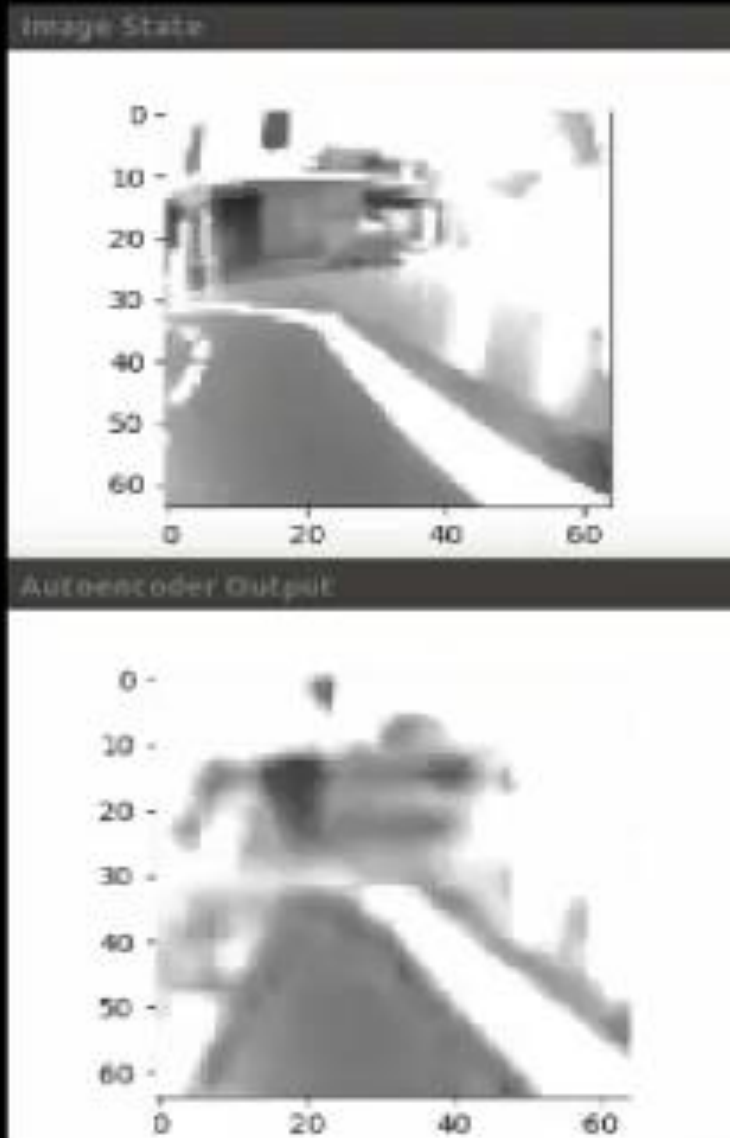
CORRECTIVE ADVICE COMMUNICATED BY HUMANS (COACH)



Deep COACH - Online

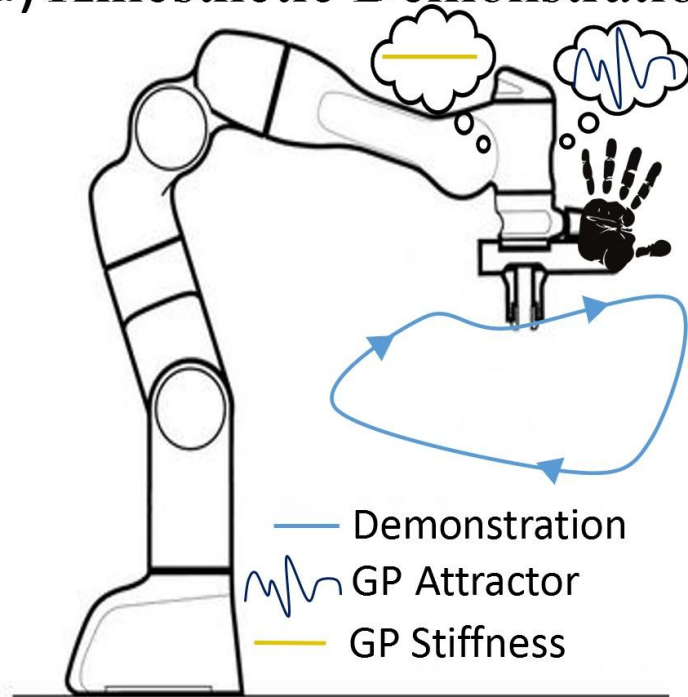




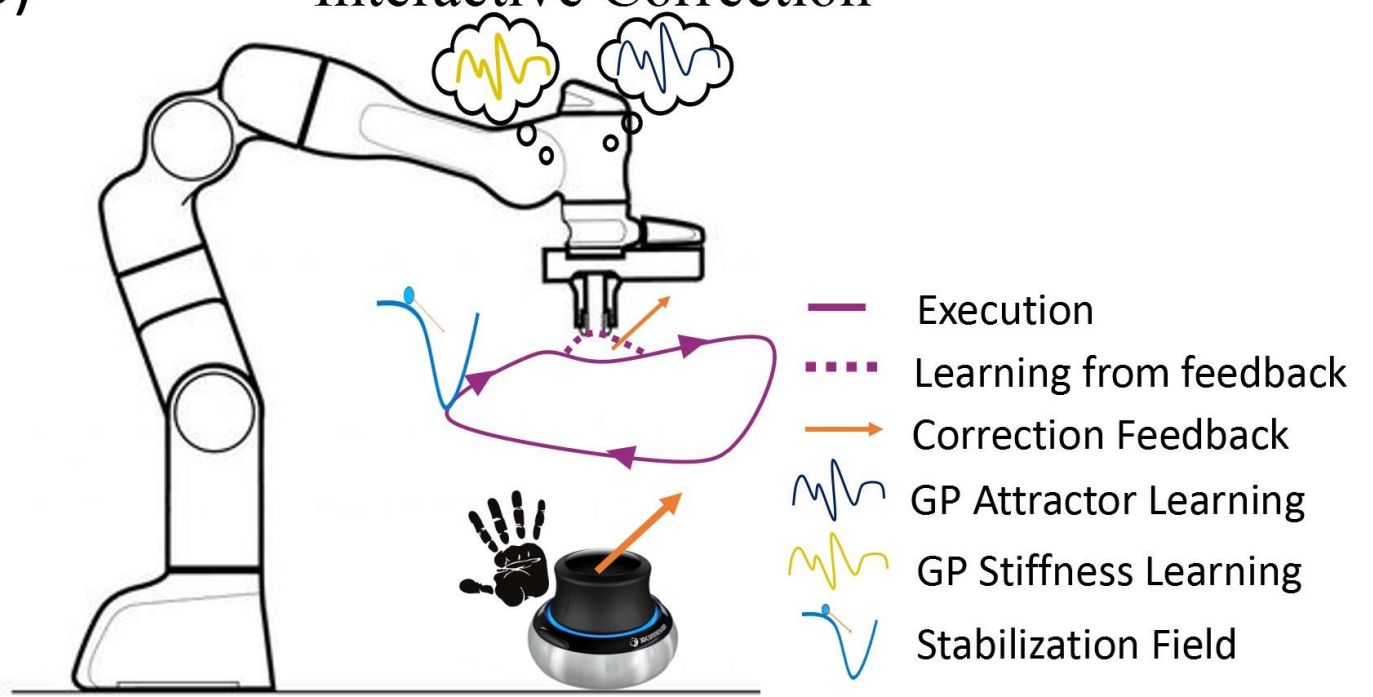


Interactive Learning of Stiffness and Attractors (ILoSA)

a) Kinesthetic Demonstration



b) Interactive Correction



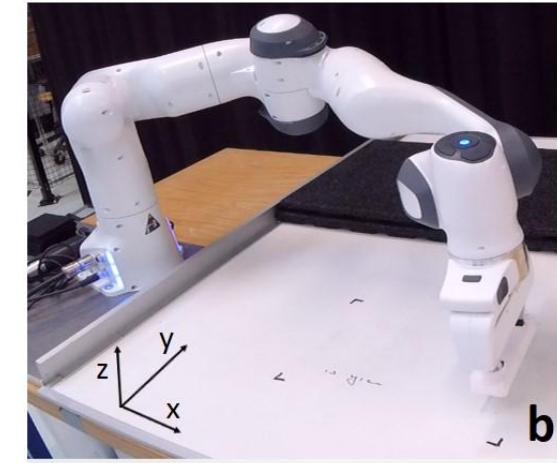
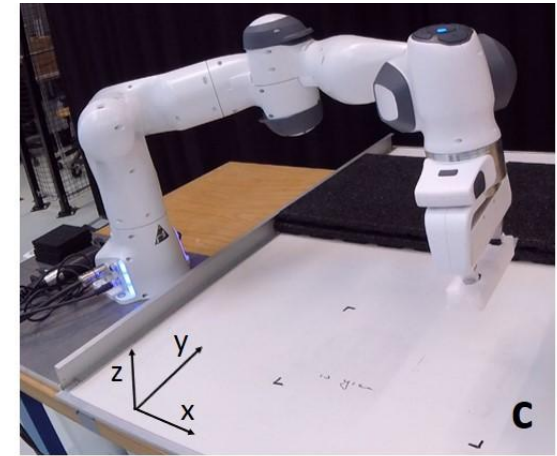
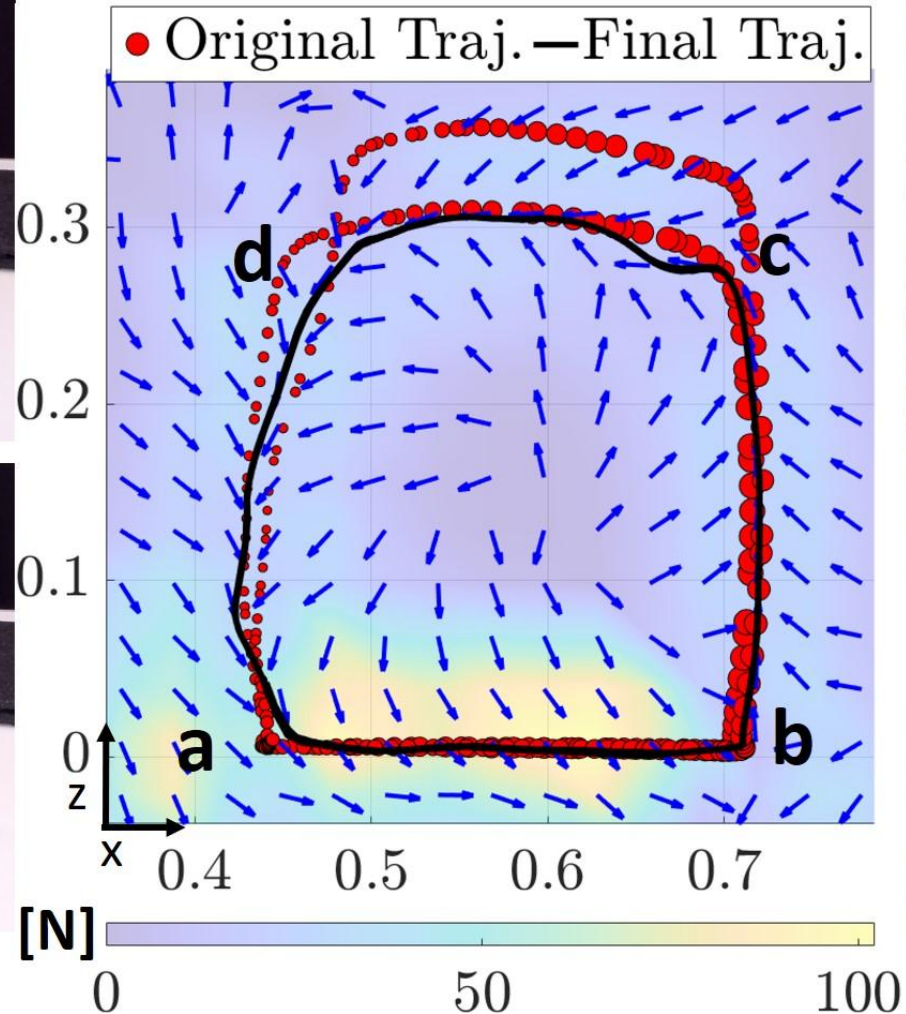
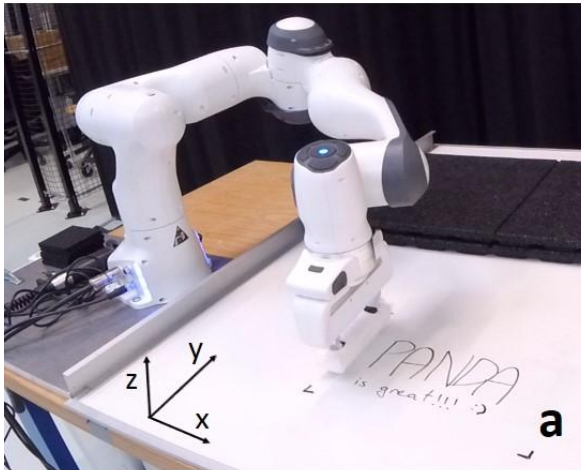
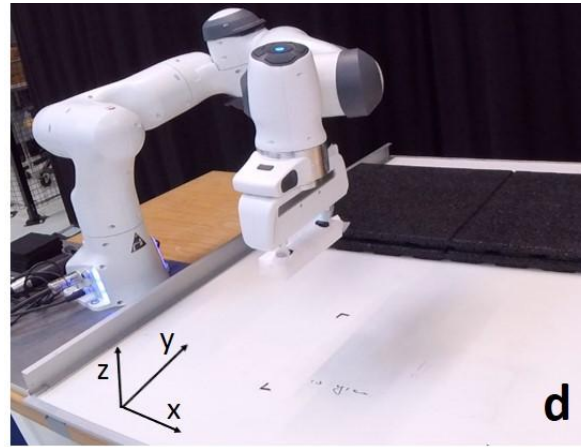
2x



Kinesthetic Demonstration

Franzese, Mészáros, Peternel, & Kober, IROS 2021

Interactive Learning of Stiffness and Attractors (ILoSA)





Kinesthetic Demonstration



Policy Execution

Resolving Ambiguities





**5 FRAMES:
WORLD FRAME,
CUCUMBER,
APPLE,
APPLES' CRATE,
CUCUMBERS'
CRATE**



**WHEN THE BOXES
ARE SWAPPED, AN
AMBIGUITY IS
DETECTED. THE
ROBOT ASKS FOR
FEEDBACK, AND THE
PUSH IN THE RIGHT
DIRECTION SOLVES
THE AMBIGUITY.**

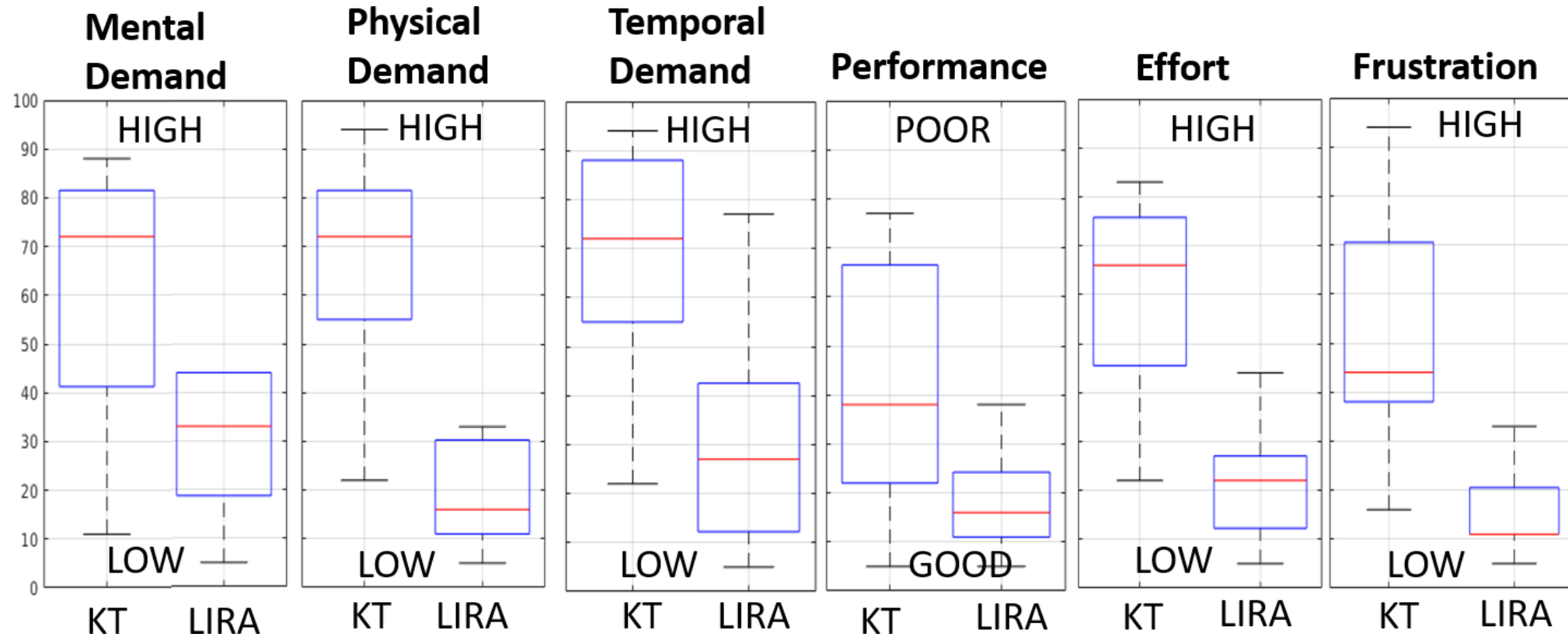
A robotic arm with a white gripper is positioned over a white table in a grocery store. The table holds several small boxes of tea or coffee. A person's hands are visible, adjusting the robot. To the left, a black crate contains various fruits like tomatoes, cucumbers, and bell peppers. In the background, there are shelves stocked with packaged goods. A computer monitor, keyboard, and mouse are on the table to the right of the robot. A text box with the title 'FIRST KINESTHETIC TEACHING' is overlaid on the left side of the image.

FIRST KINESTHETIC TEACHING

A white robotic arm with a blue light on its gripper is positioned on a white table in a grocery store aisle. The table also holds a computer monitor, keyboard, mouse, and some papers. To the left of the table is a black crate containing a cardboard box with tomatoes, a cucumber, and a zebra. The background shows shelves stocked with various grocery items like bags of chips and boxes of cereal. The scene is captured from a high angle, showing the robot's position relative to the table and the surrounding environment.

SECOND ITERATION WITH LIRA

NASA-TLX



Interactive Reinforcement Learning

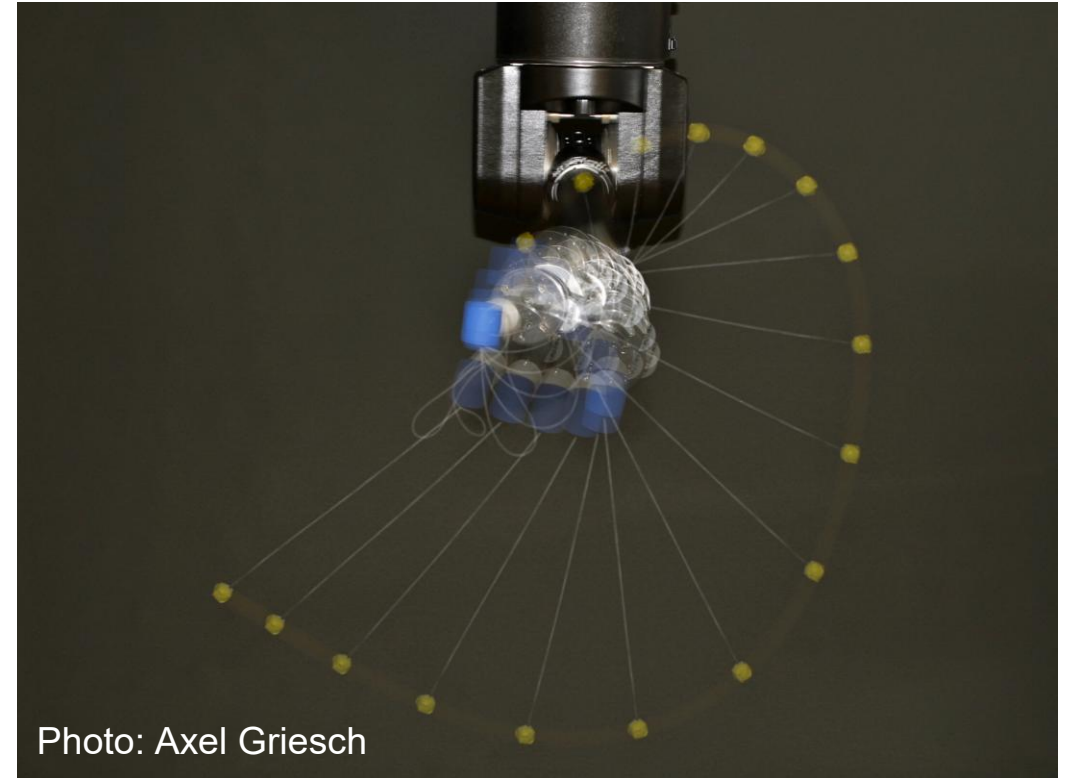
Example: Ball-in-a-Cup

Human



35 trials

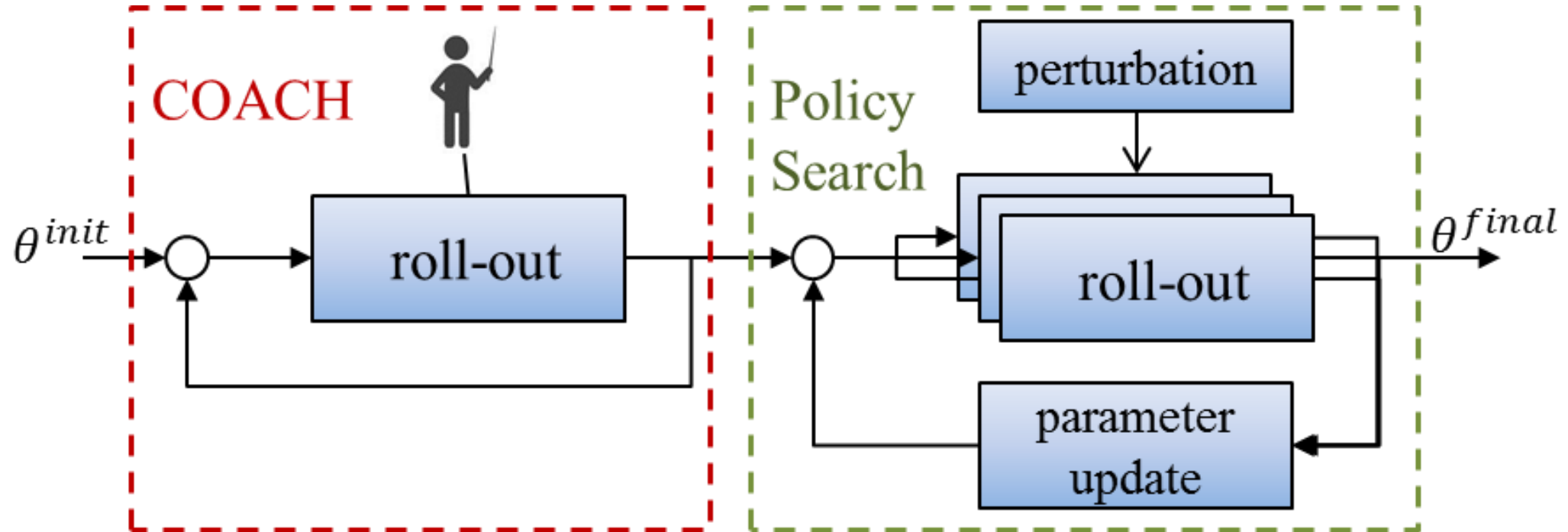
Robot



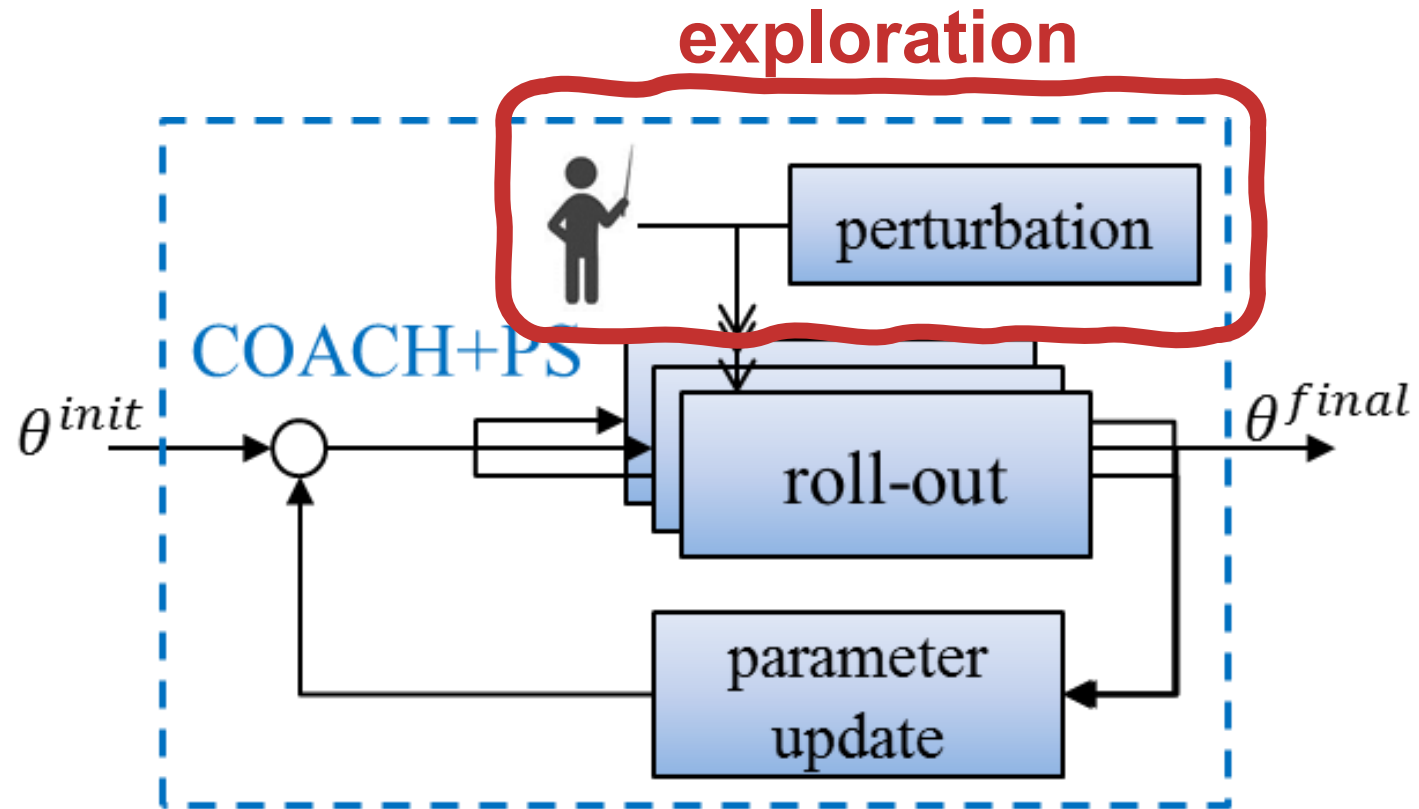
?? trials



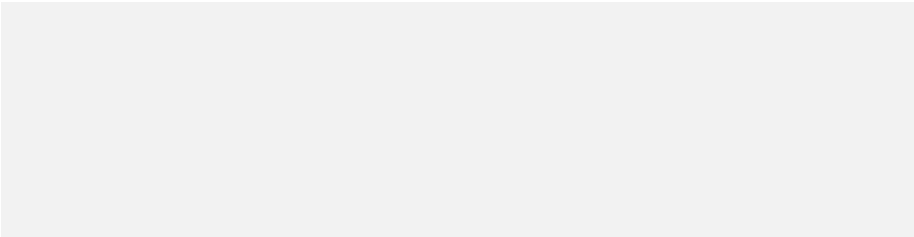
IL + RL: Sequential

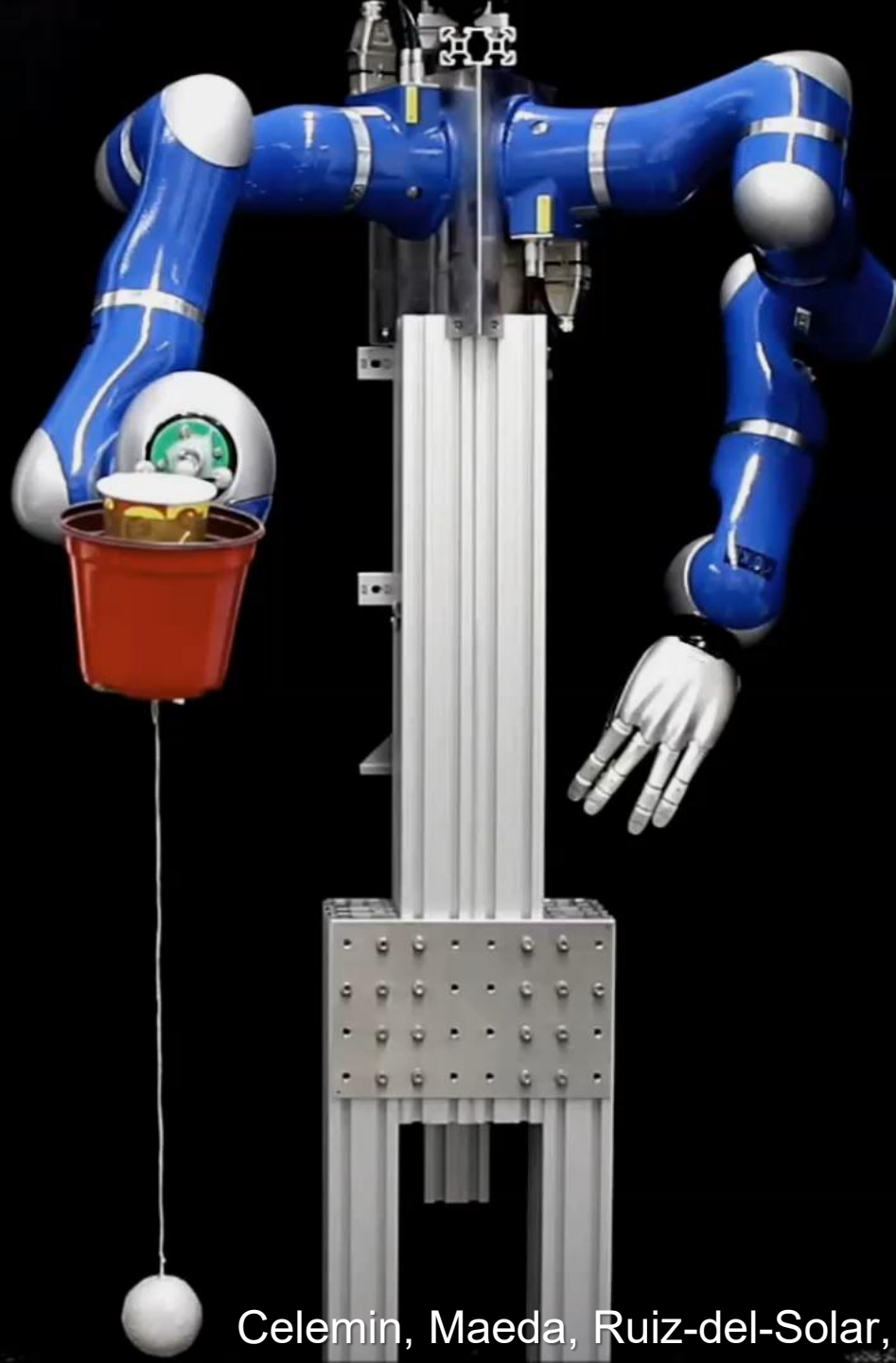


IL + RL: Simultaneous

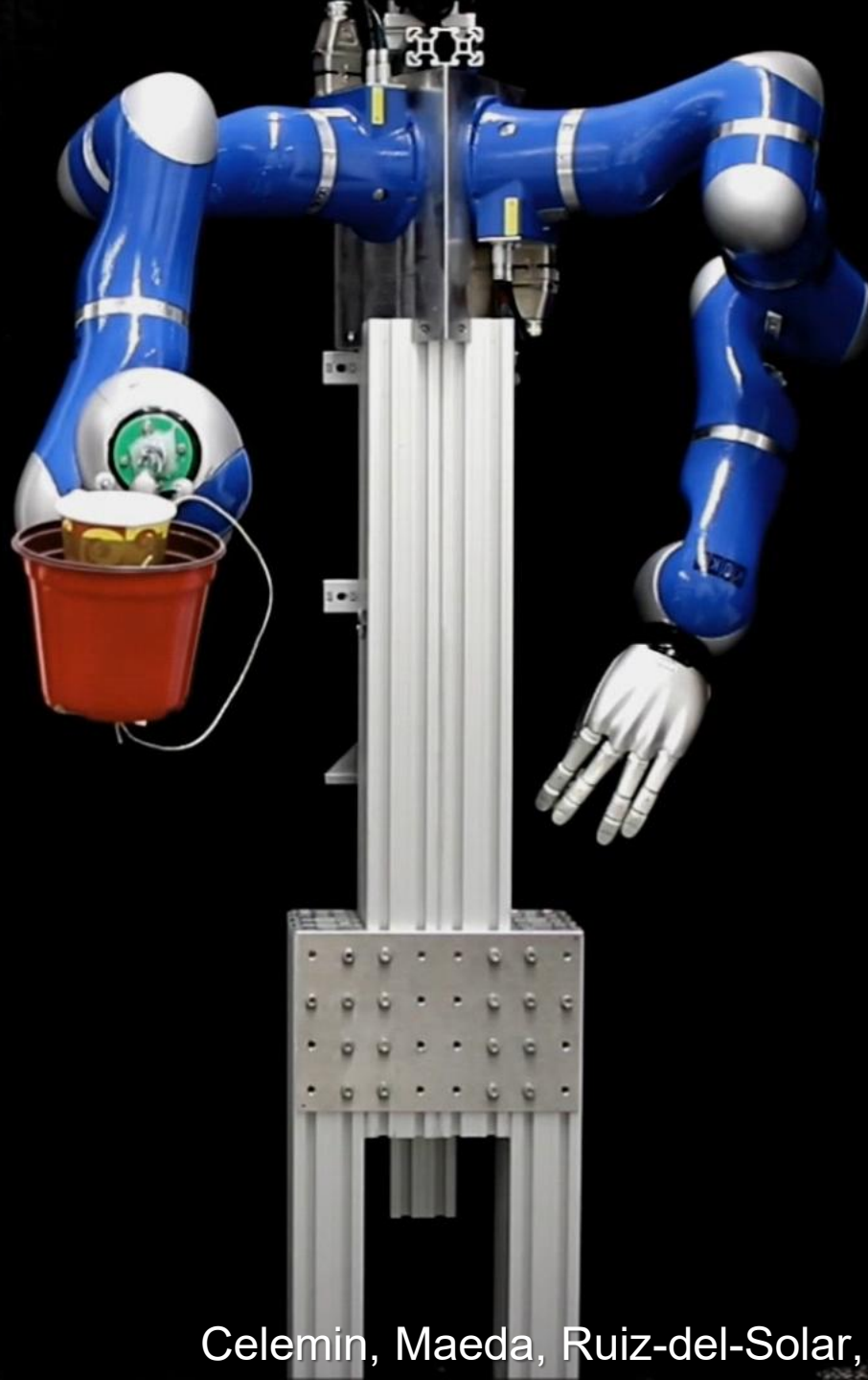


Policy Search

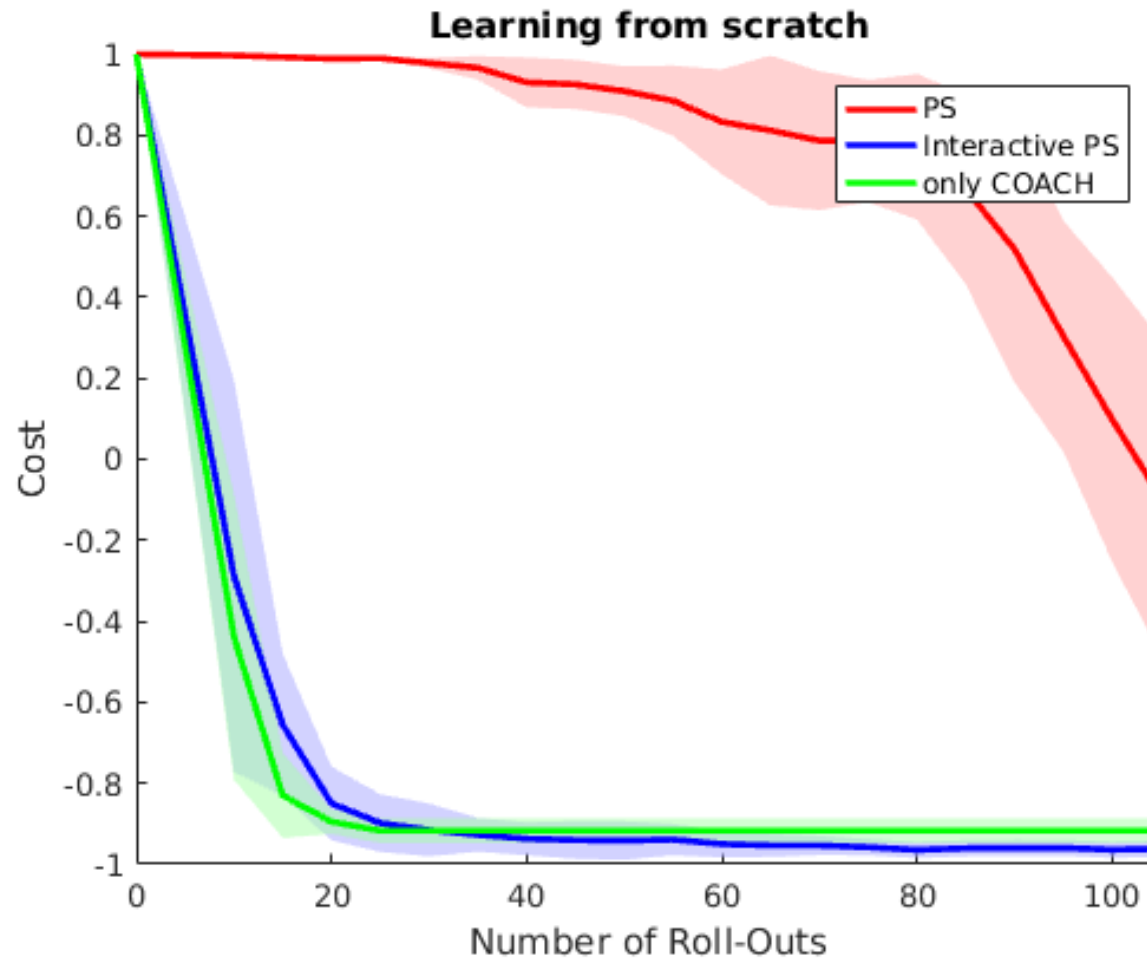
```
1: repeat
2:   Explore: first roll-out with the current policy  $\pi_k$ 
       $w_1 = w^{[k]}$ 
3:   for  $m = 1 \dots M$  do
4:     
5:
6:
7:
8:      $[w_m]_t \leftarrow PS\_exploration(w^{[k]})$ 
9:      $RunRollOut([w_m]_t)$ 
10:  Evaluate: cost of each roll-out
       $[R_m]_t = \phi_T + \sum_{t=0}^T r_t^{[m]}$ 
11:  Update: Compute new policy parameters using
       $w^{[k+1]} \leftarrow Update([w_m]_t, [R_m]_t)$ 
12: until Policy converges  $\pi_{k+1} \approx \pi_k$ 
```



1X

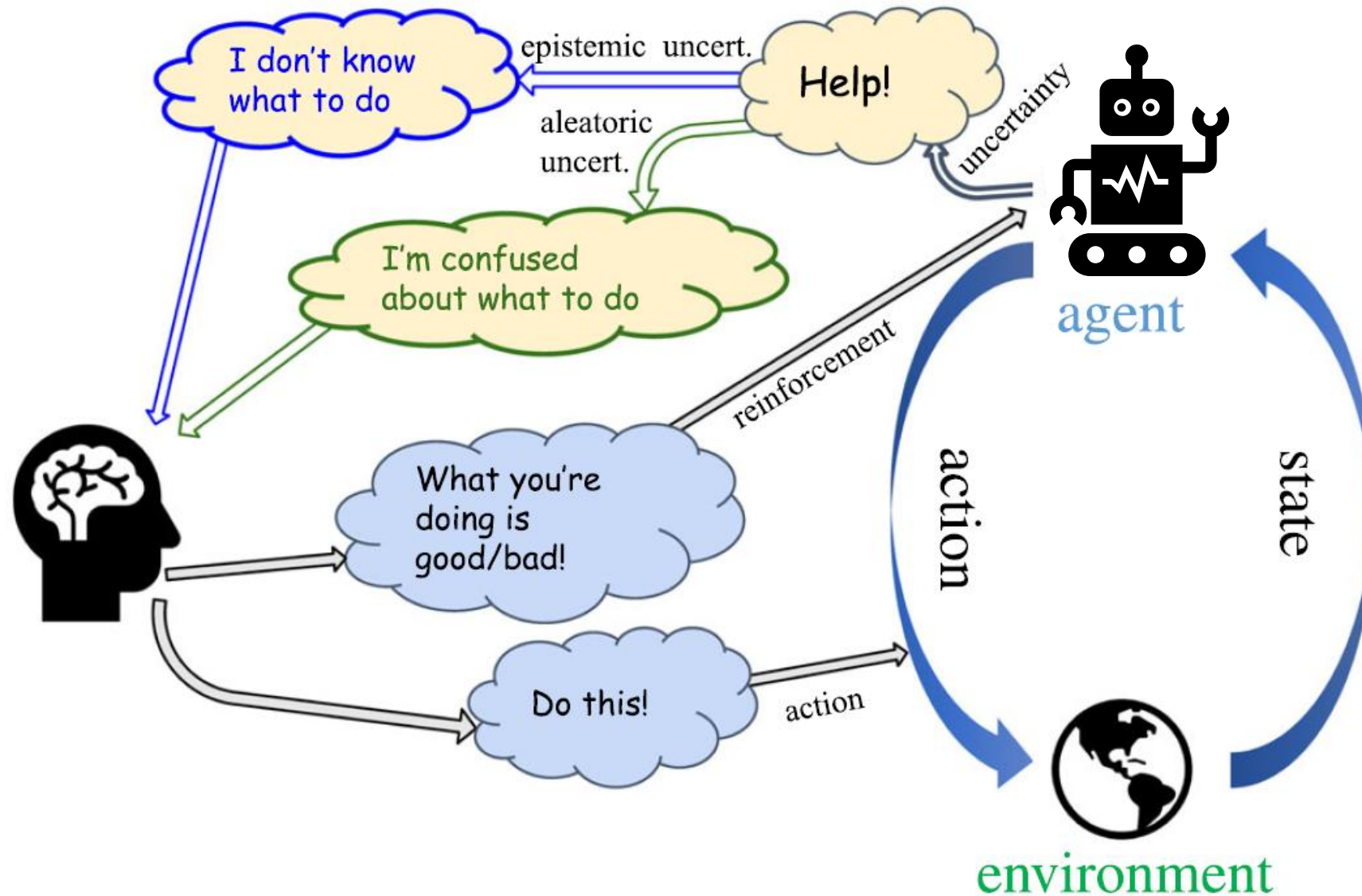


Results



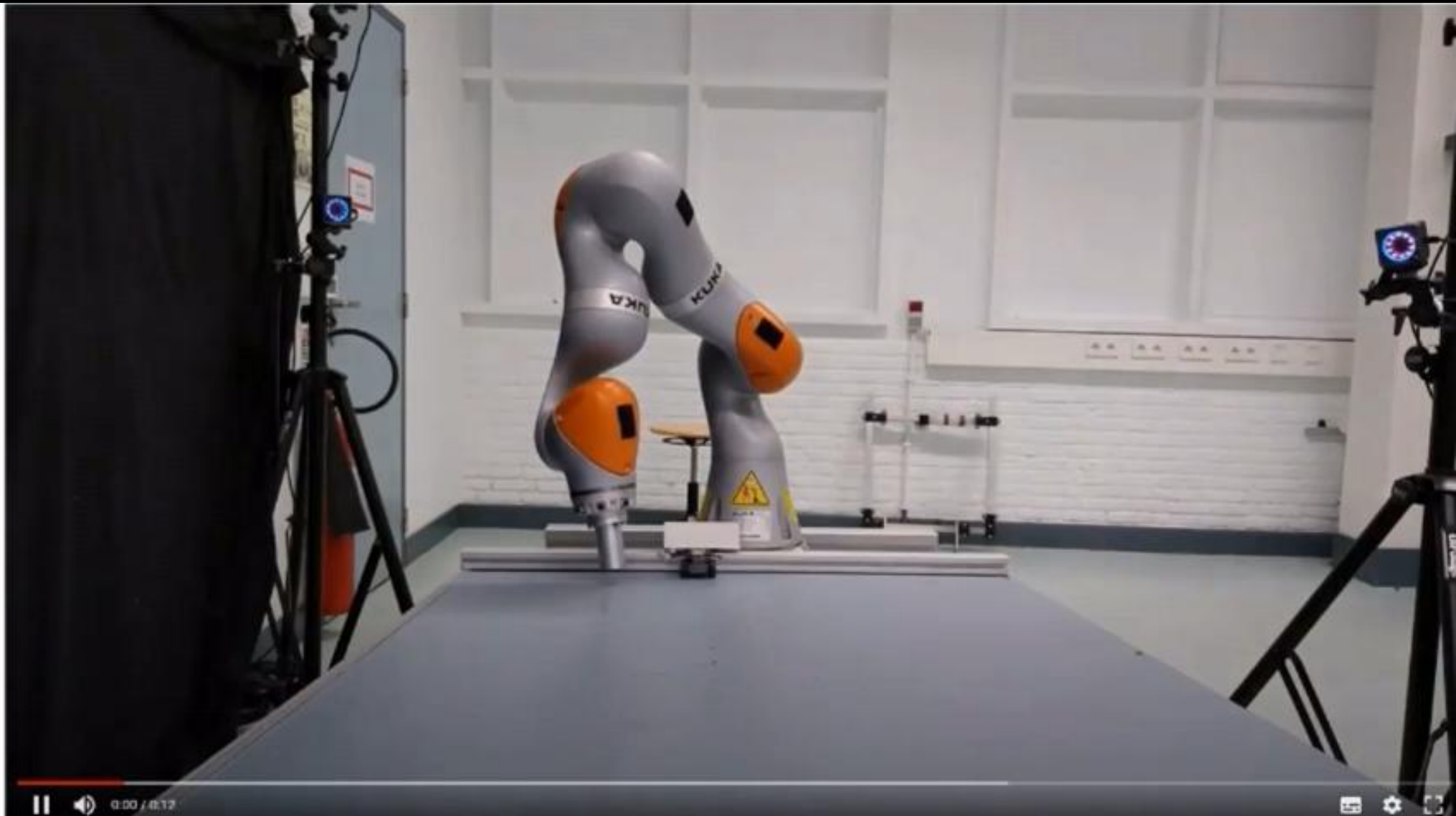
Putting It All Together

Feedback: when and how?



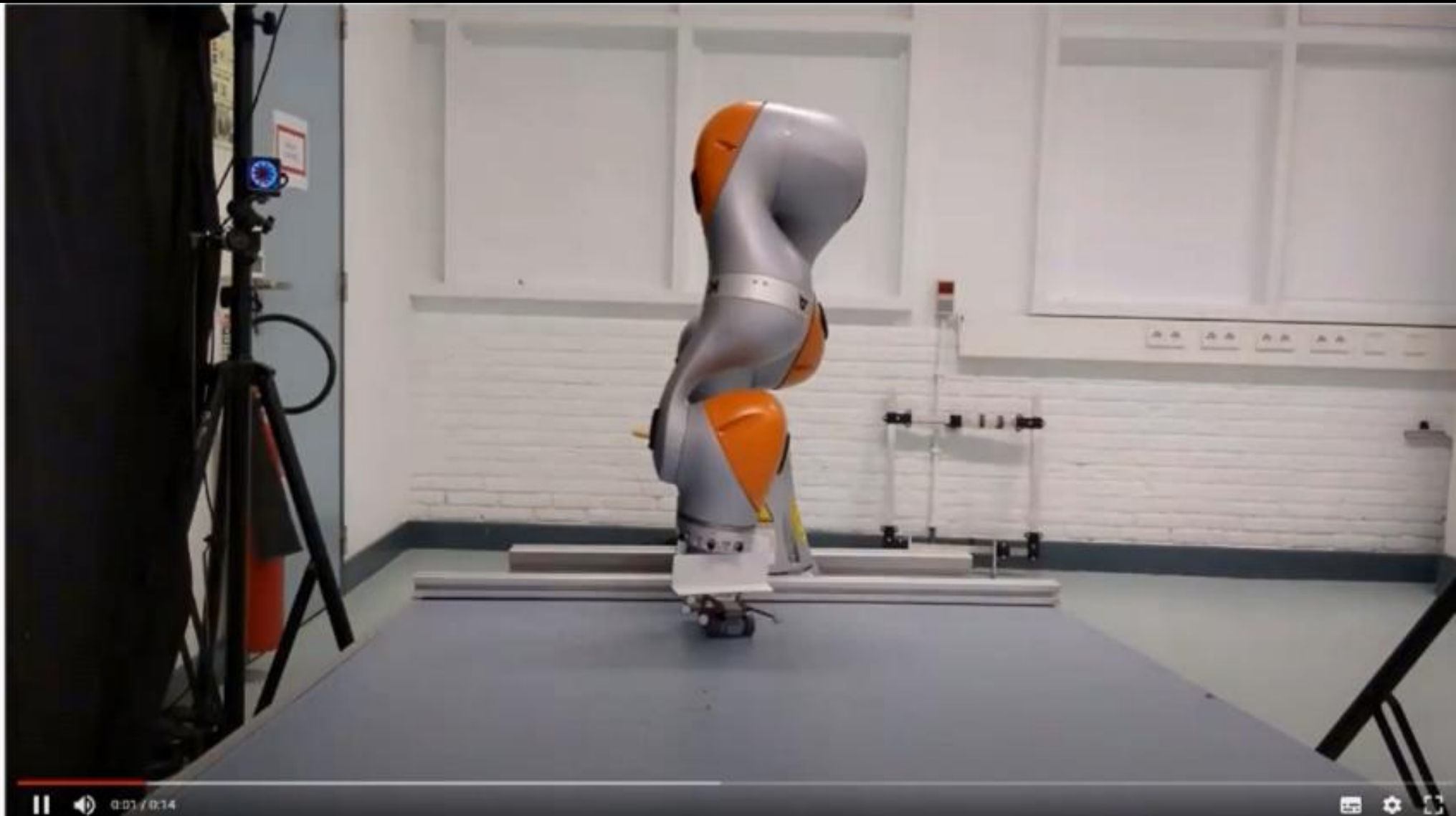
During
learning

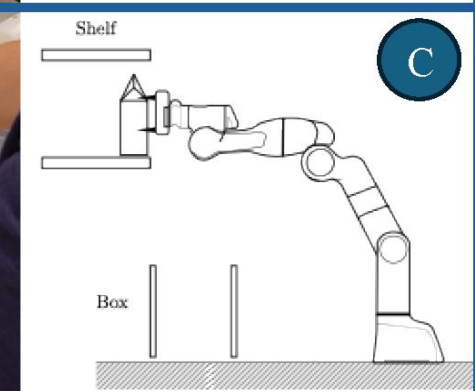
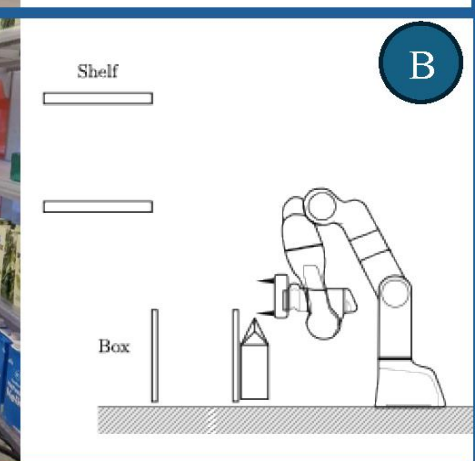
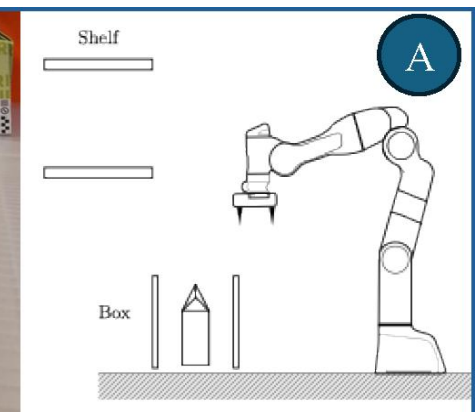
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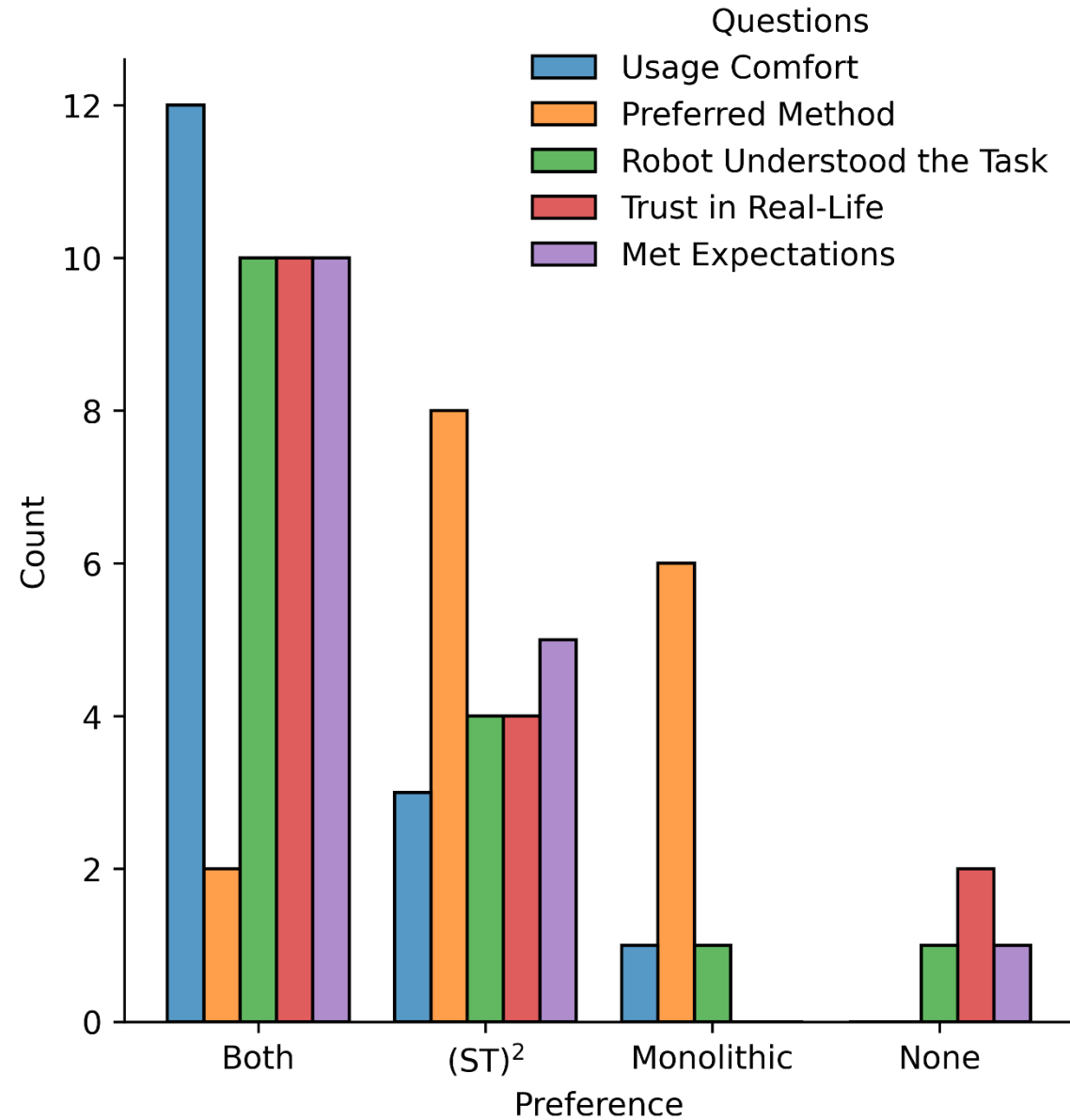
After
learning

2x





Wide Variability



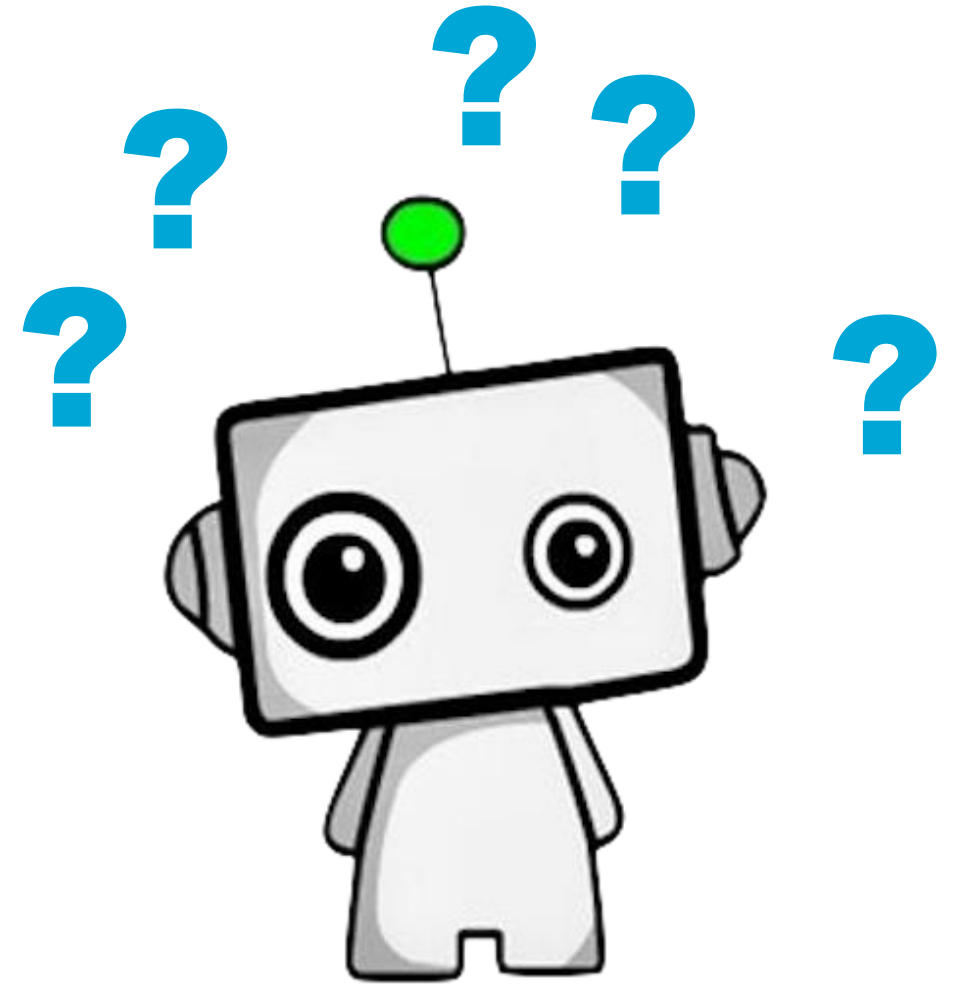
WINNER: 2024 euROBIN Manipulation Skill Versatility Challenge



Conclusion

and even more challenges...

- What to unlearn?
- Multiple strategies
- Transfer or not?
- Emphasized demonstrations
- ...



Summary

- Teaching through interactions
 - Speed up robot learning
 - Complimentary strengths & weaknesses
 - Combine with other methods
- How do humans like to teach?

Interactive Imitation Learning in Robotics: A Survey

Suggested Citation: Carlos Celemin*, Rodrigo Pérez-Dattari*, Eugenio Chisari*, Giovanni Franzese*, Leandro de Souza Rosa, Ravi Prakash, Zlatan Ajanović, Marta Ferraz, Abhinav Valada and Jens Kober (xx), "Interactive Imitation Learning in Robotics: A Survey", : Vol. xx, No. xx, pp 1–xx. DOI: xx.xxxx/XXXXXXXXXX.

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*These authors contributed equally to this work.

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