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

Robot Learning Through Interactions

Jens Kober

TU Delft

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

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Not Only Humans...

Unsplash
Petr Magera

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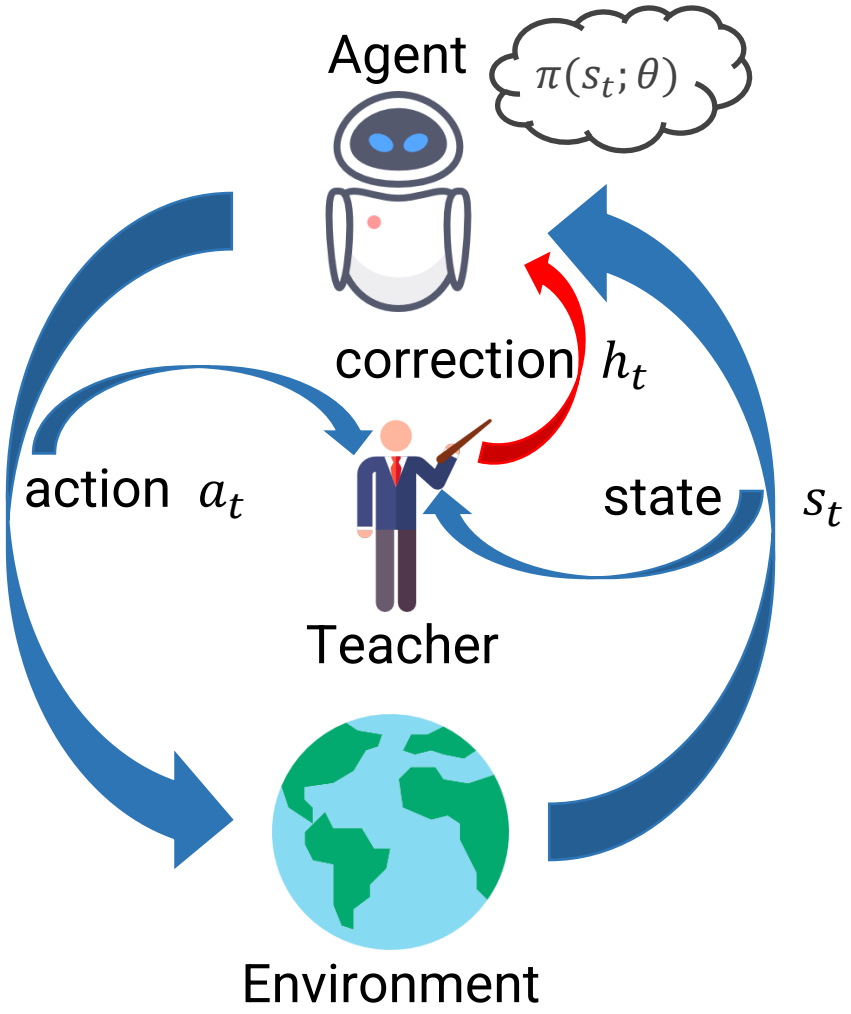
Rama

Interactive Learning



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Interactive Imitation Learning

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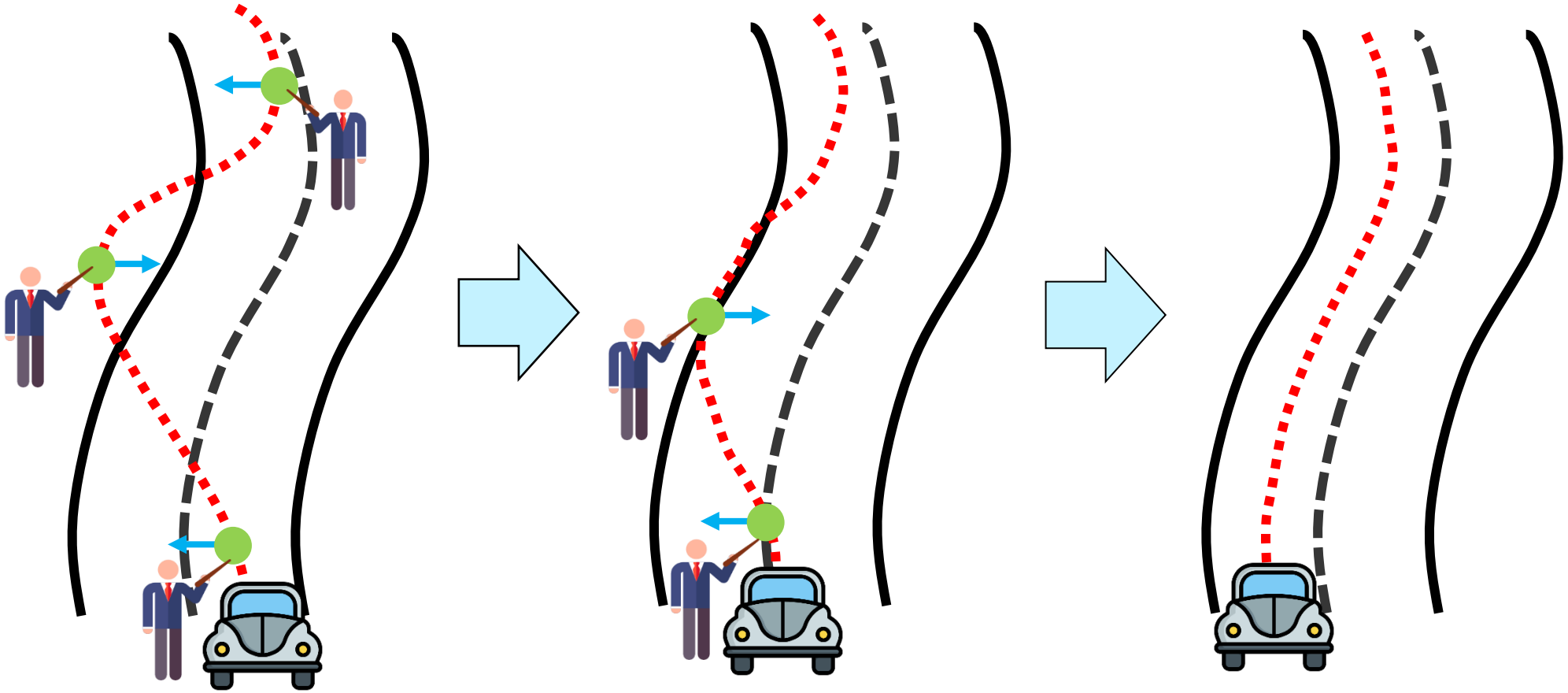
COrrective Advice Communicated by Humans (COACH)



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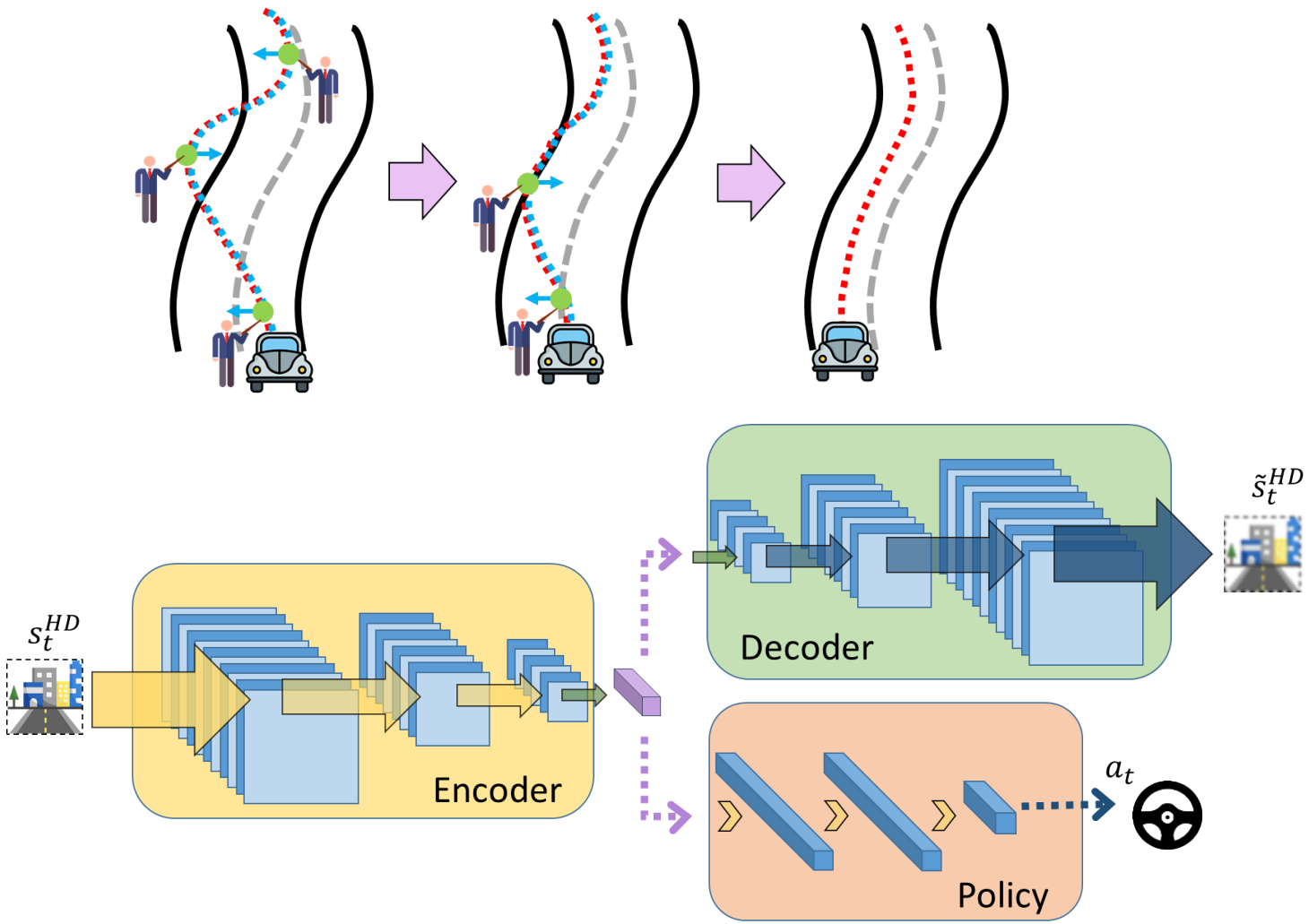
Celemin & Ruiz Del Solar, JIRS 2018

Deep COACH - Online



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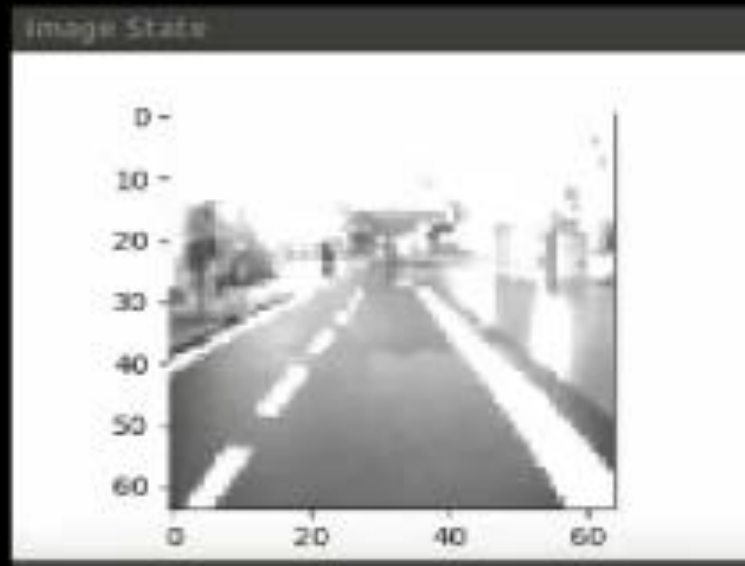
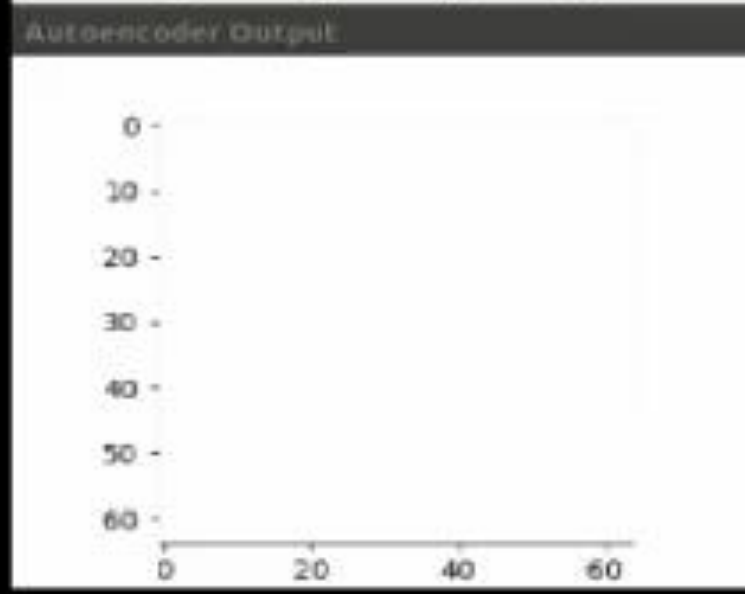
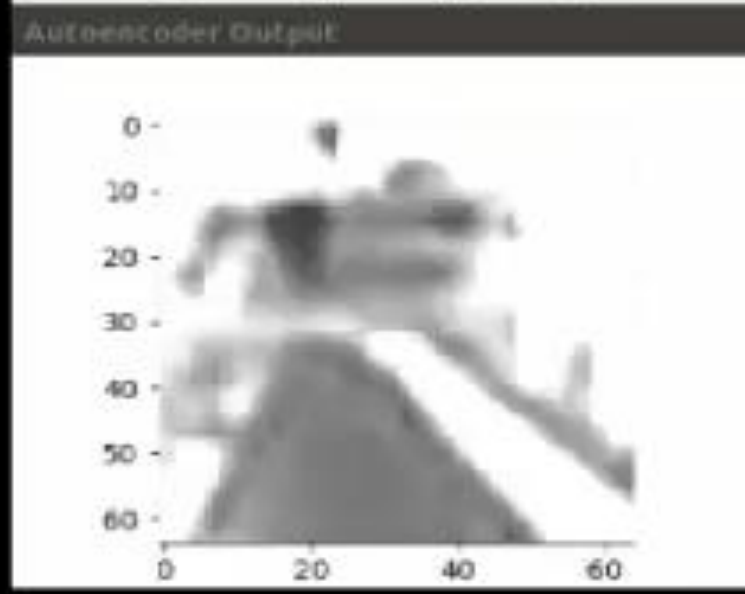
Pérez, Celemin, Ruiz-del-Solar, & Kober, ICRA 2019



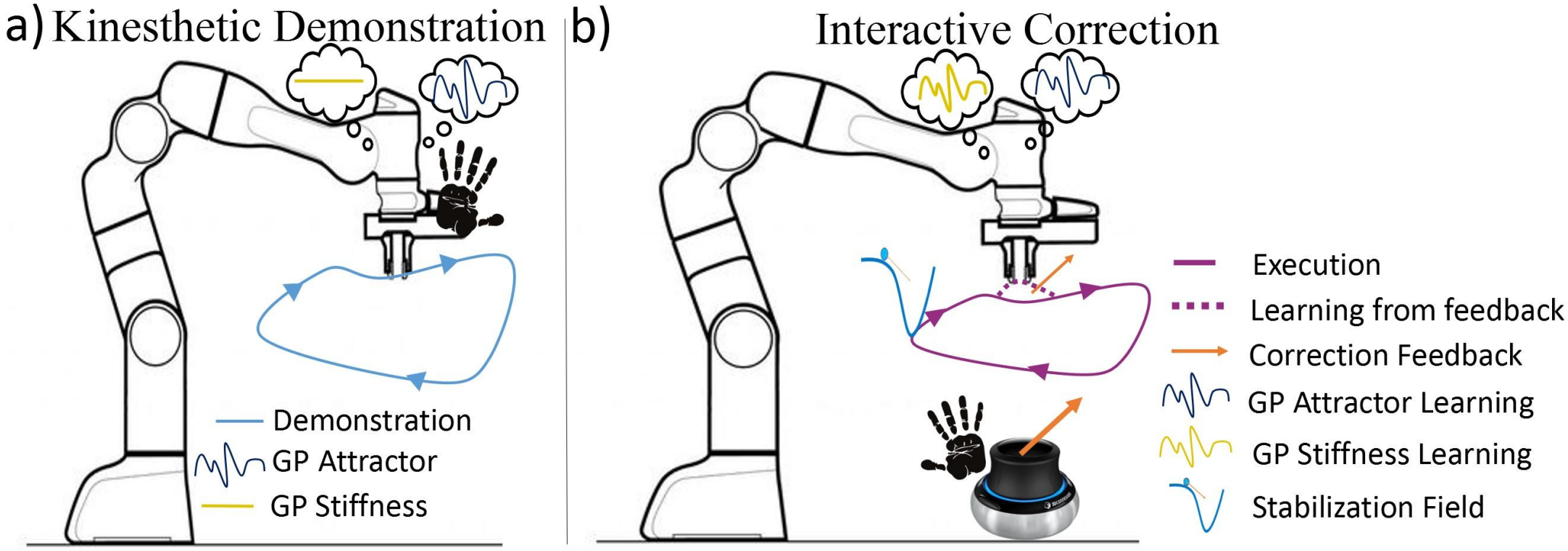


Pérez, Celemin, Ruiz-del-Solar, & Kober, ICRA 2019



Pérez, Celemin, Ruiz-del-Solar, & Kober, ICRA 2019

Interactive Learning of Stiffness and Attractors (ILoSA)



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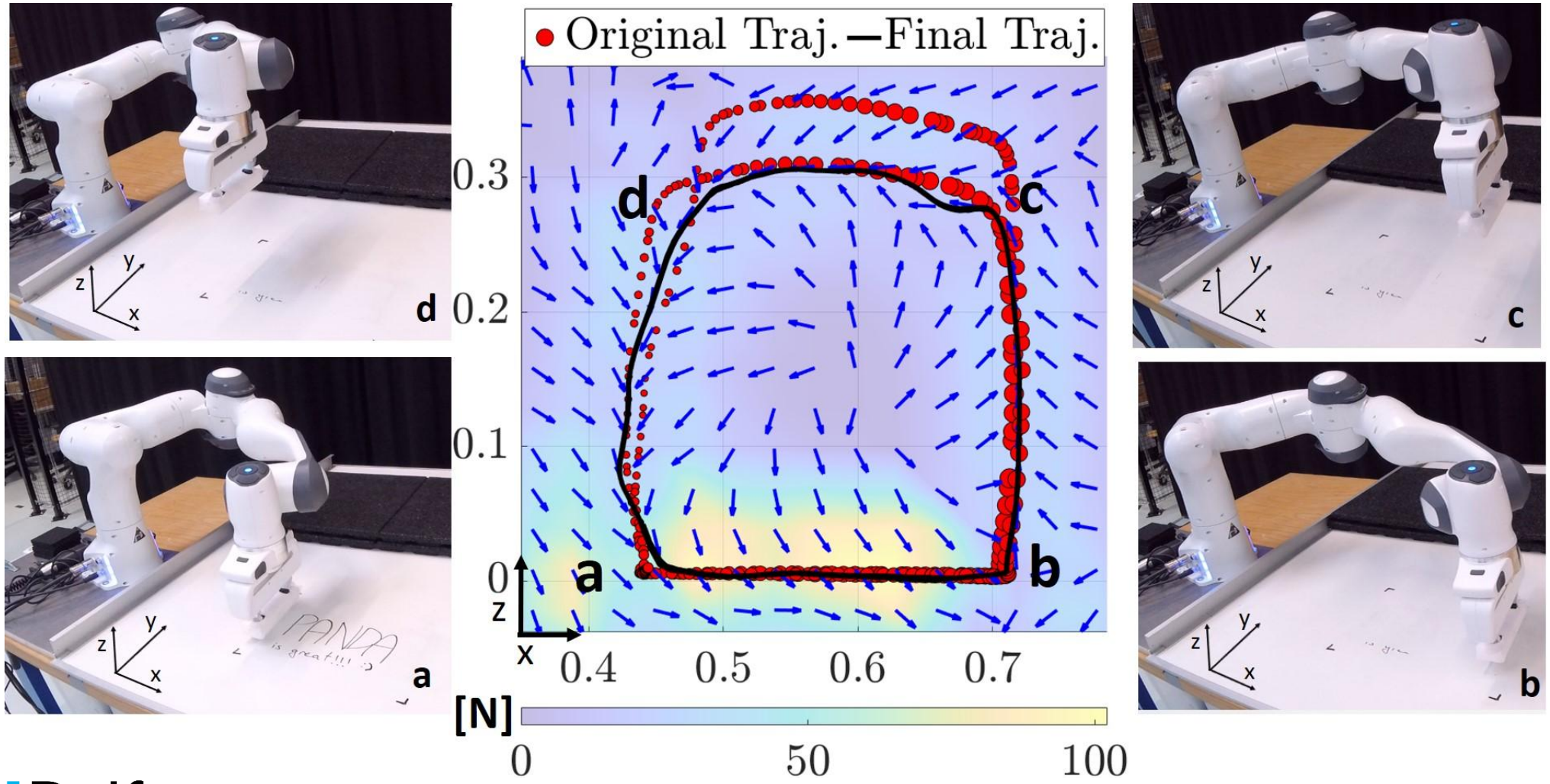
Franzese, Mészáros, Peternel, & Kober, IROS 2021

Kinesthetic Demonstration

Franzese, Mészáros, Peternel, & Kober, IROS 2021

Interactive Learning of Stiffness and Attractors (ILoSA)



Franzese, Mészáros, Peternel, & Kober, IROS 2021

Kinesthetic Demonstration

Mészáros, Franzese, & Kober, RA-L 2022

Mészáros, Franzese, & Kober, RA-L 2022

Resolving Ambiguities

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Franzese, Celemin, & Kober, CoRL2020

Franzese, Celemin, & Kober, CoRL2020

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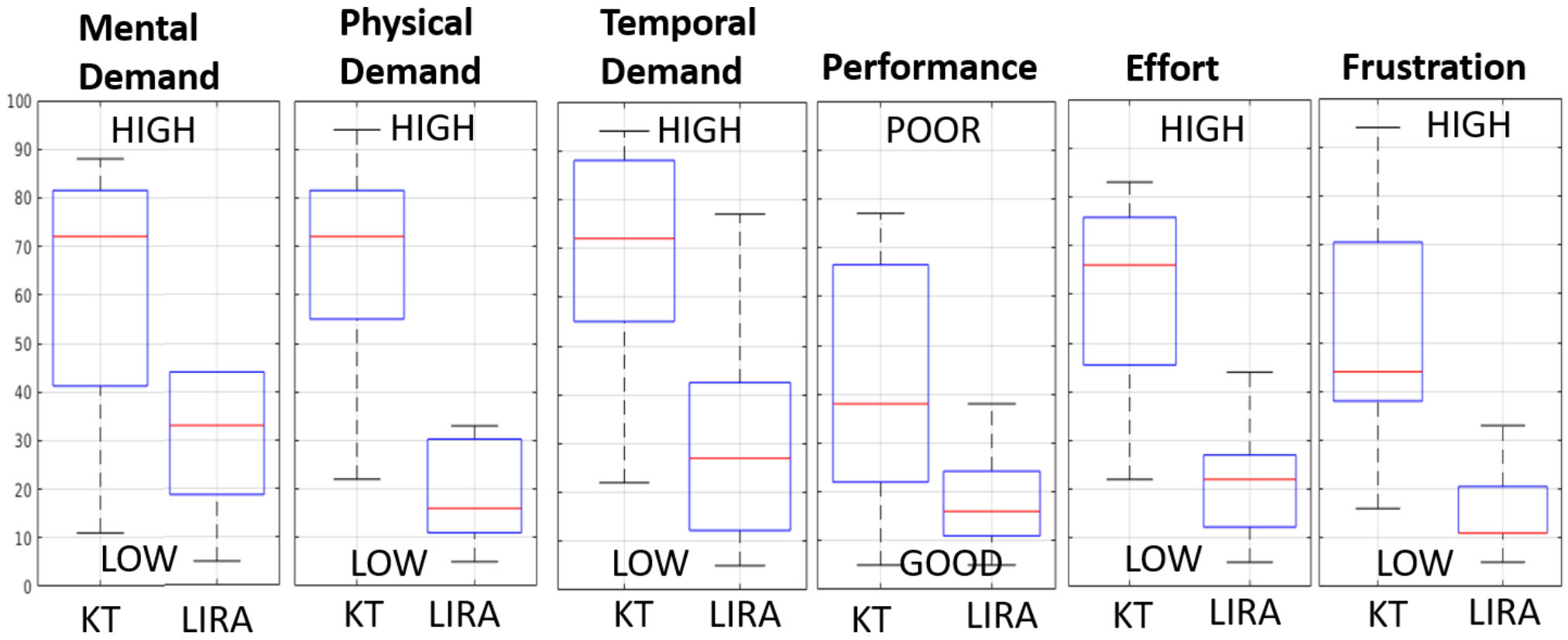
Franzese, Celemin, & Kober, CoRL2020

NASA-TLX



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Franzese, Celemin, & Kober, CoRL2020

Interactive Reinforcement Learning

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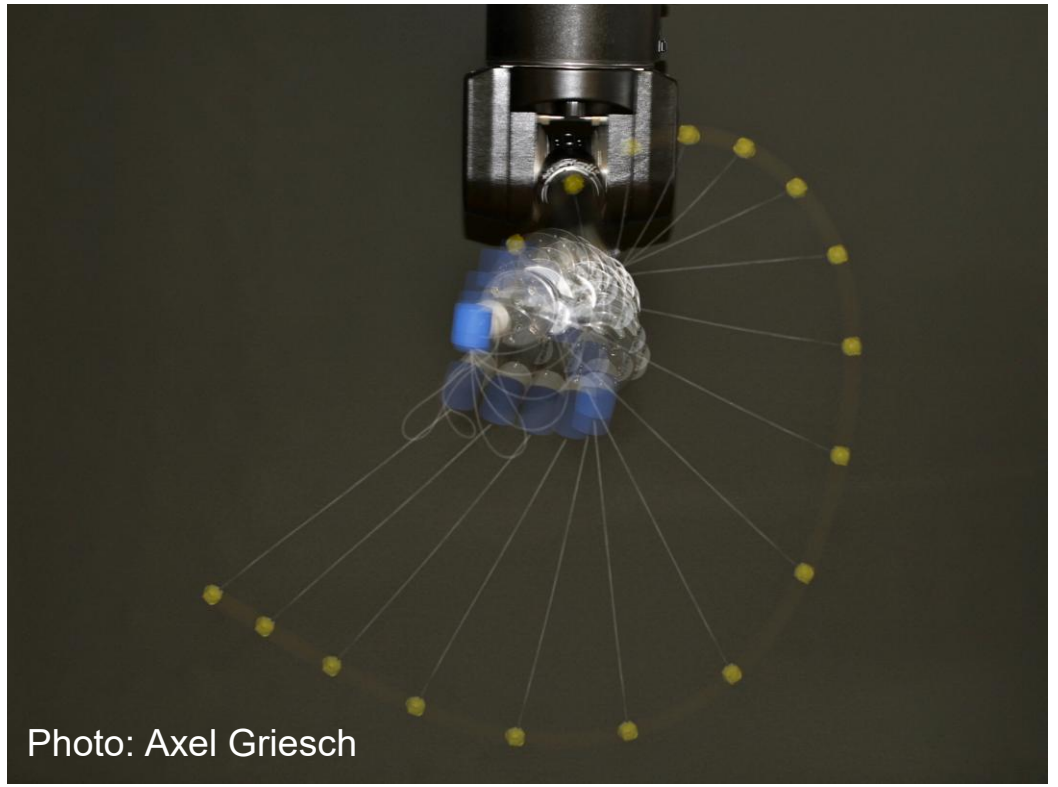
Example: Ball-in-a-Cup

Human

35 trials

Robot



?? trials

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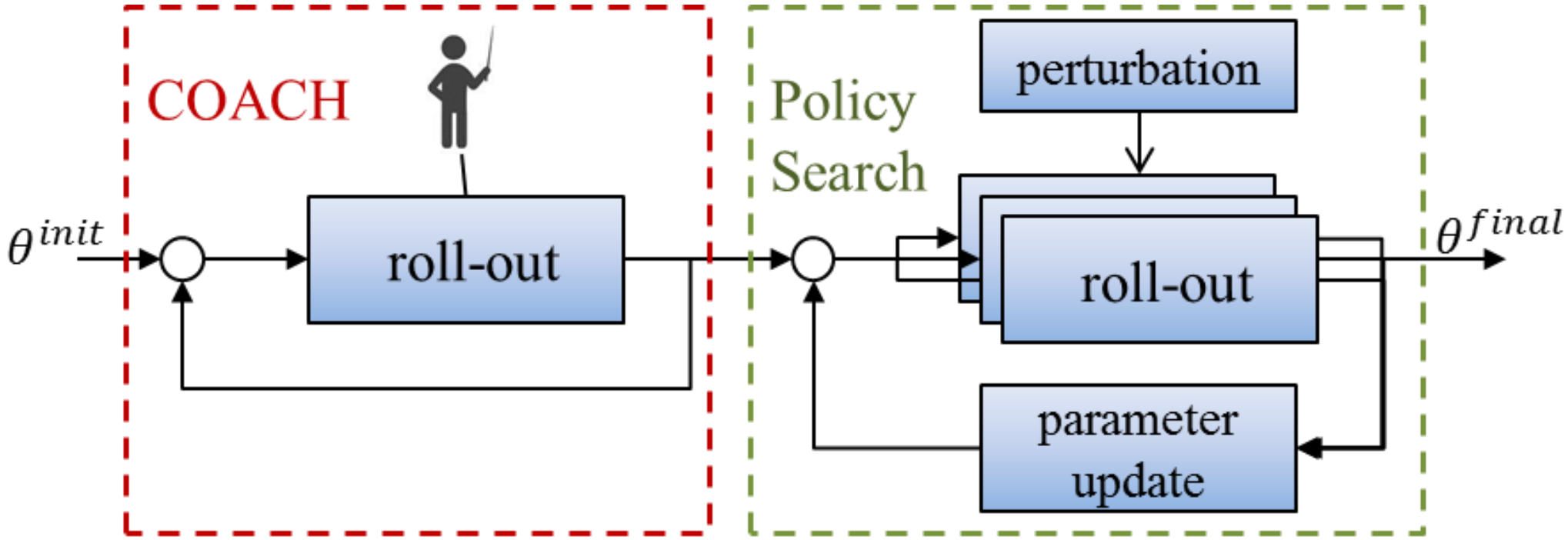
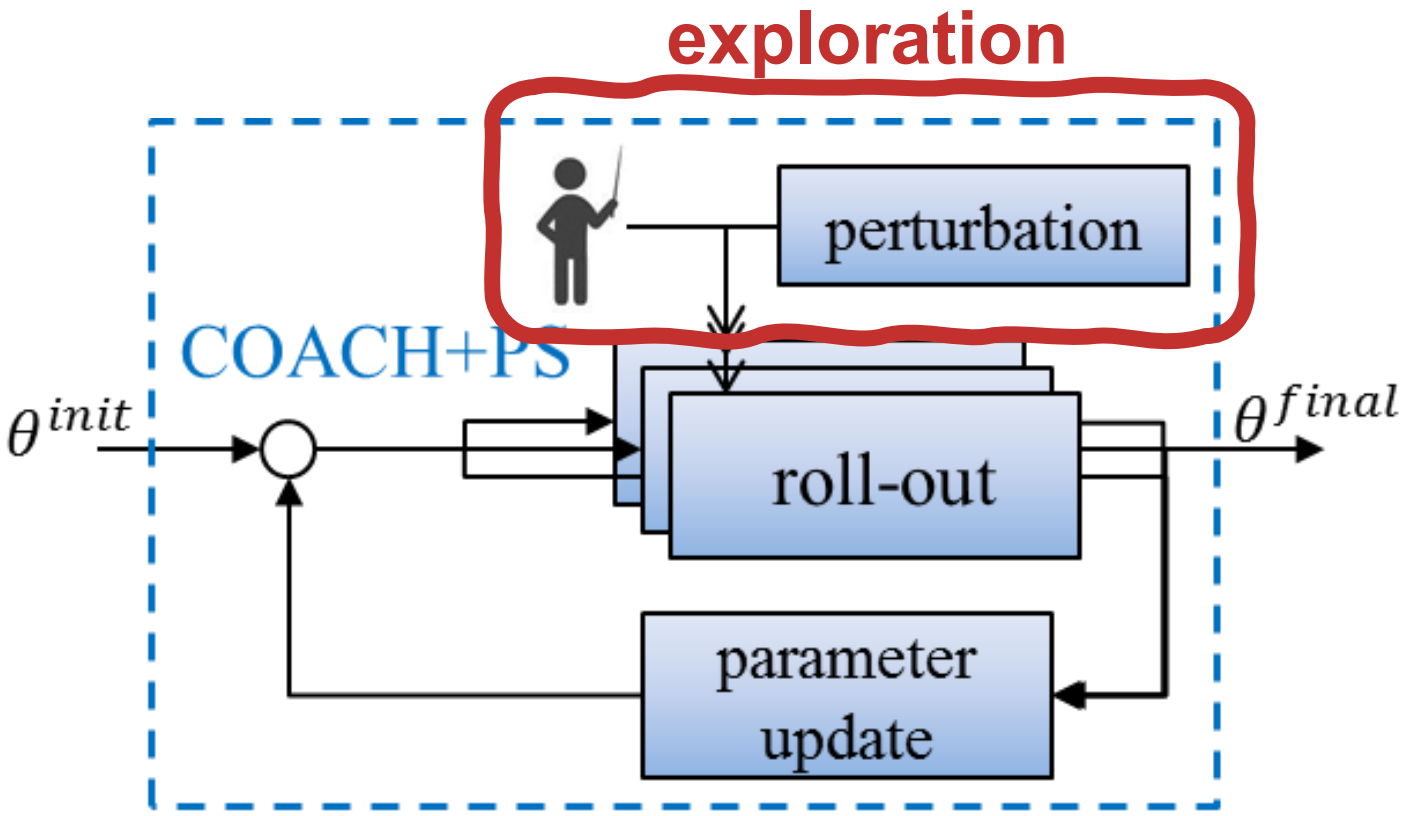
Kober & Peters, NeurIPS 2008

IL + RL: Sequential



Celemin, Maeda, Ruiz-del-Solar, Peters, & Kober, IJRR 2019

IL + RL: Simultaneous



Celemin, Maeda, Ruiz-del-Solar, Peters, & Kober, IJRR 2019

Policy Search

1: **repeat**
2: **Explore:** first roll-out with the current policy π_k
$w_1 = w^{[k]}$
3: **for** $m = 1...M$ **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 $\pi_{k+1} \approx \pi_k$

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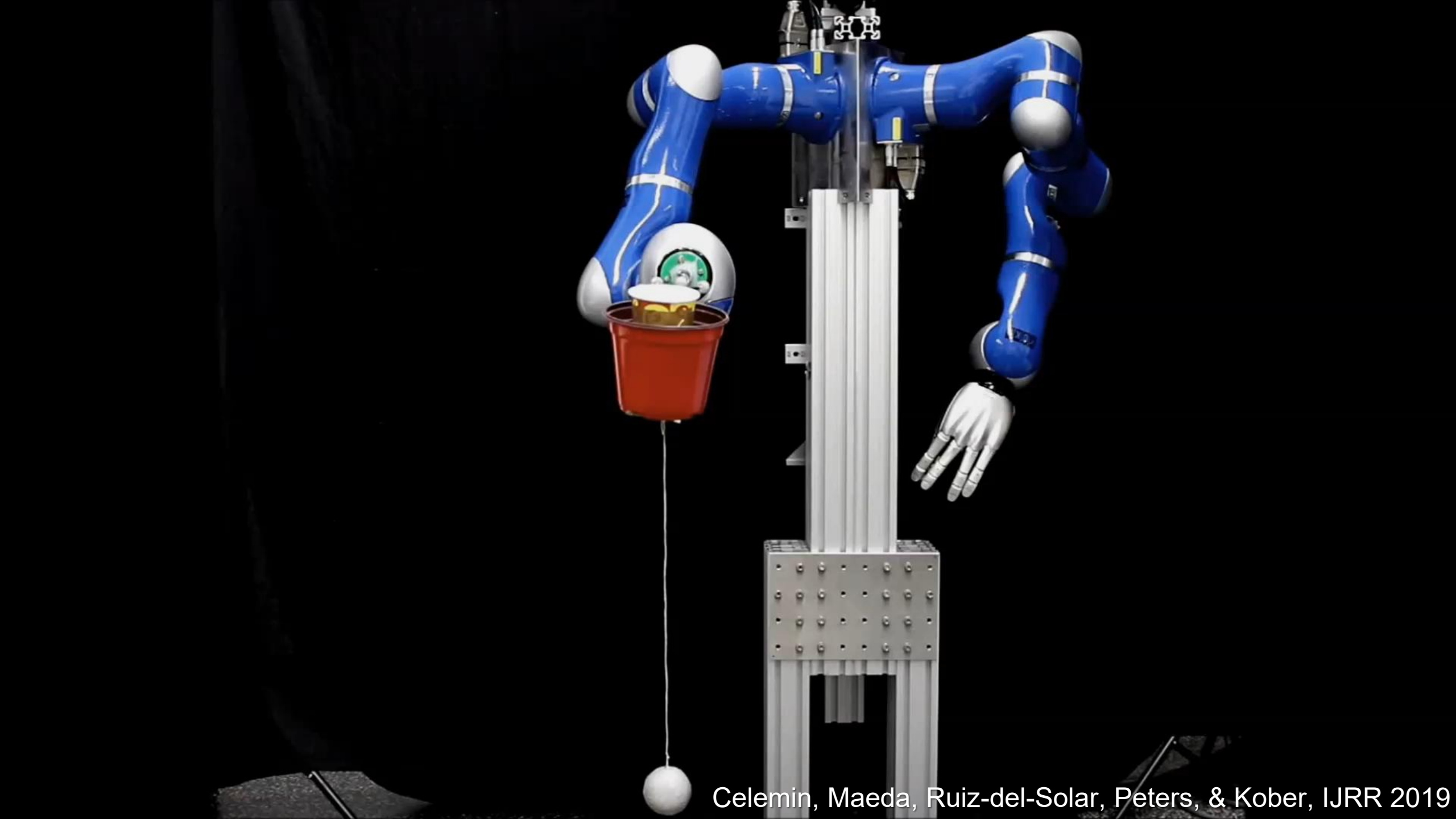
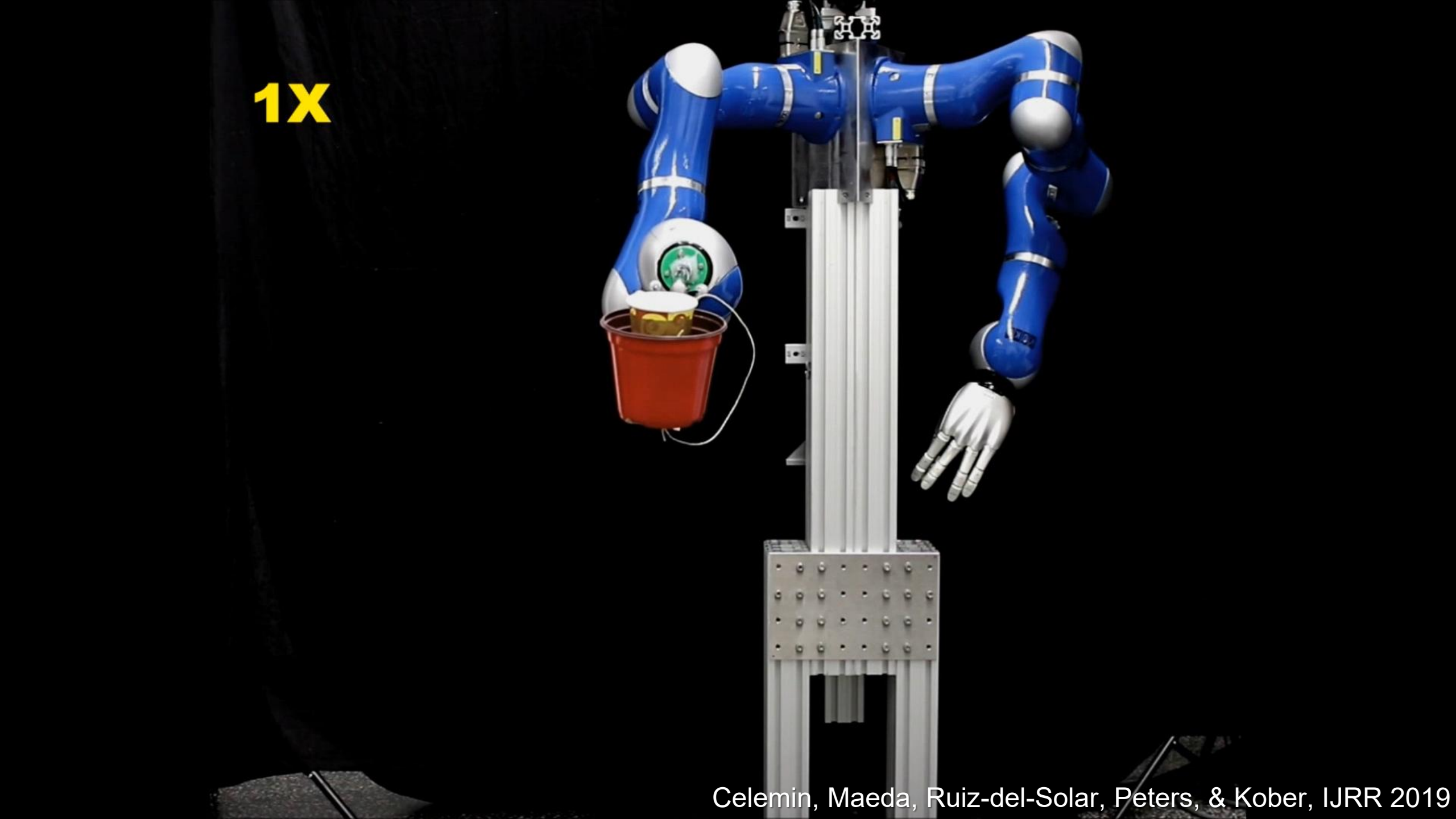
Celemin, Maeda, Ruiz-del-Solar, Peters, & Kober, IJRR 2019

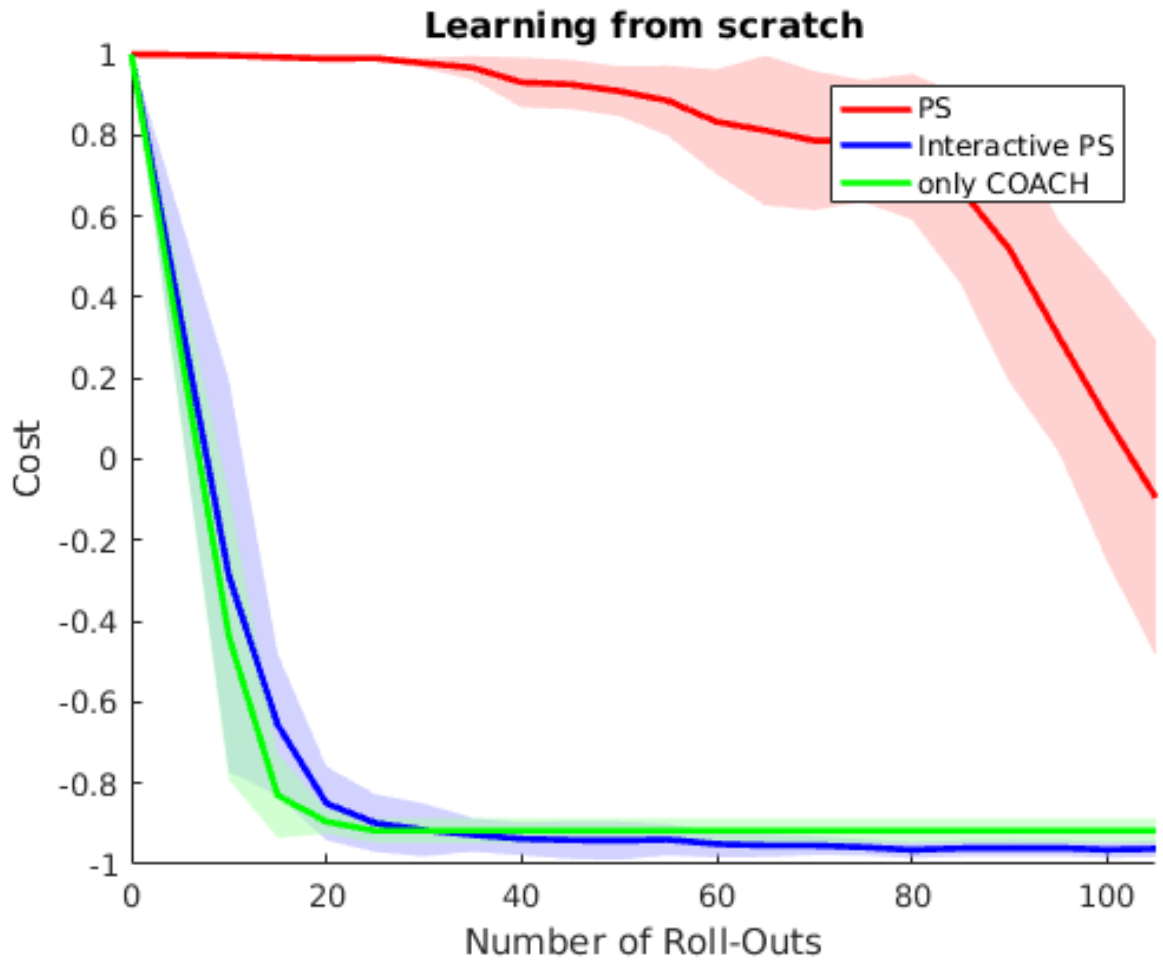


Celemin, Maeda, Ruiz-del-Solar, Peters, & Kober, IJRR 2019



Celemin, Maeda, Ruiz-del-Solar, Peters, & Kober, IJRR 2019

Results



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Celemin, Maeda, Ruiz-del-Solar, Peters, & Kober, IJRR 2019

Putting It All Together

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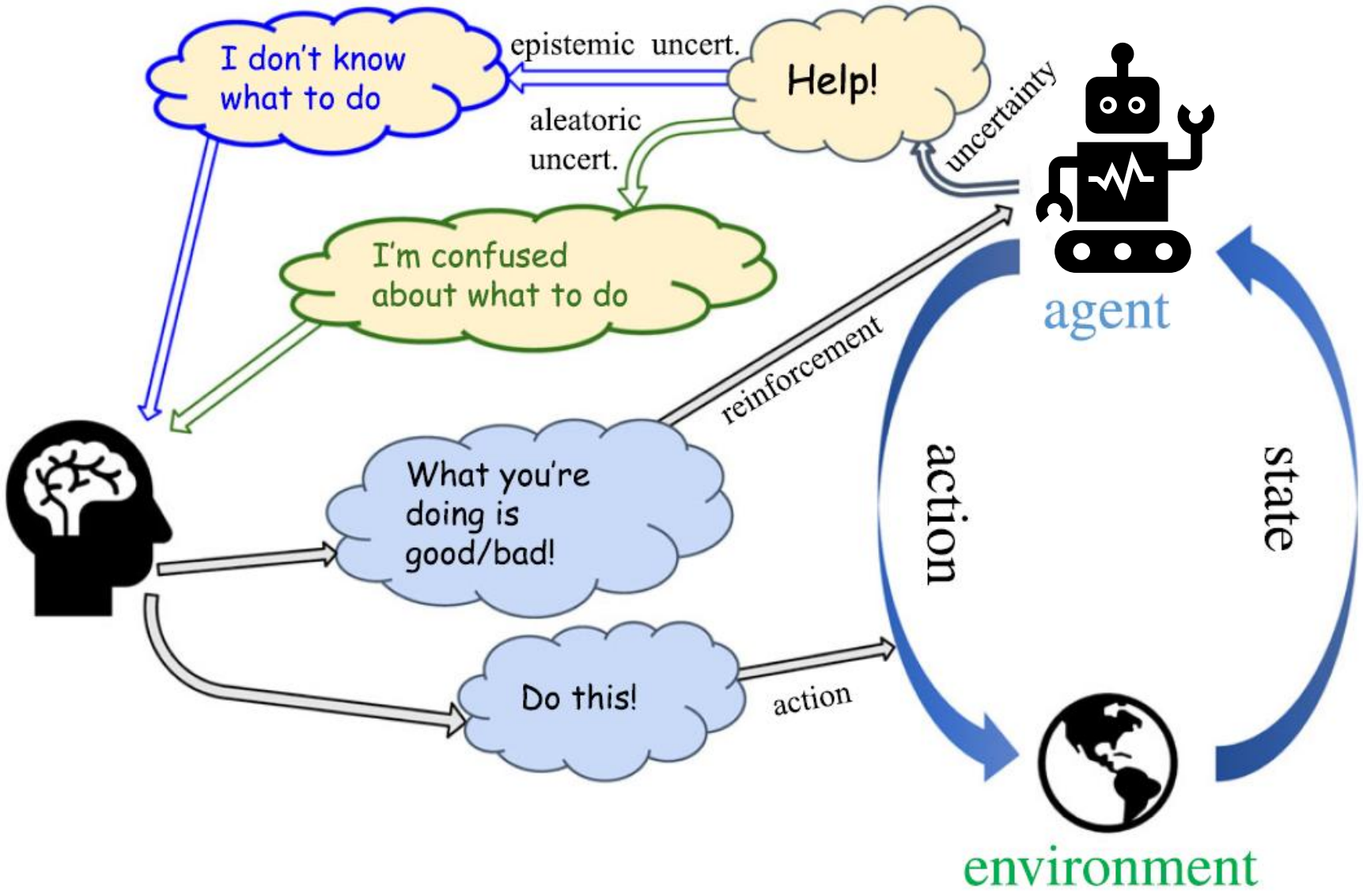
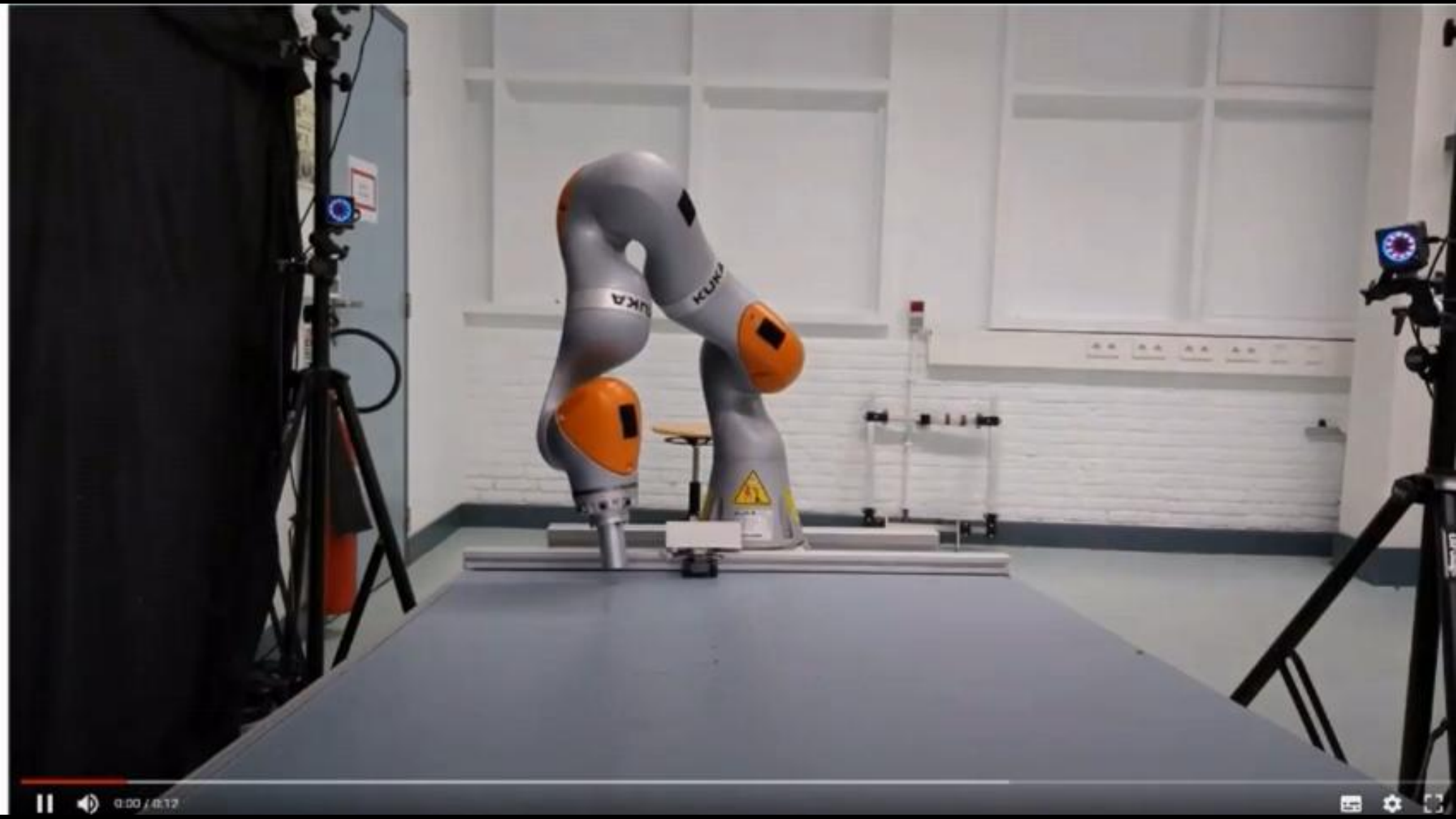
Feedback: when and how?



Celemin & Kober, NCA 2023

During learning

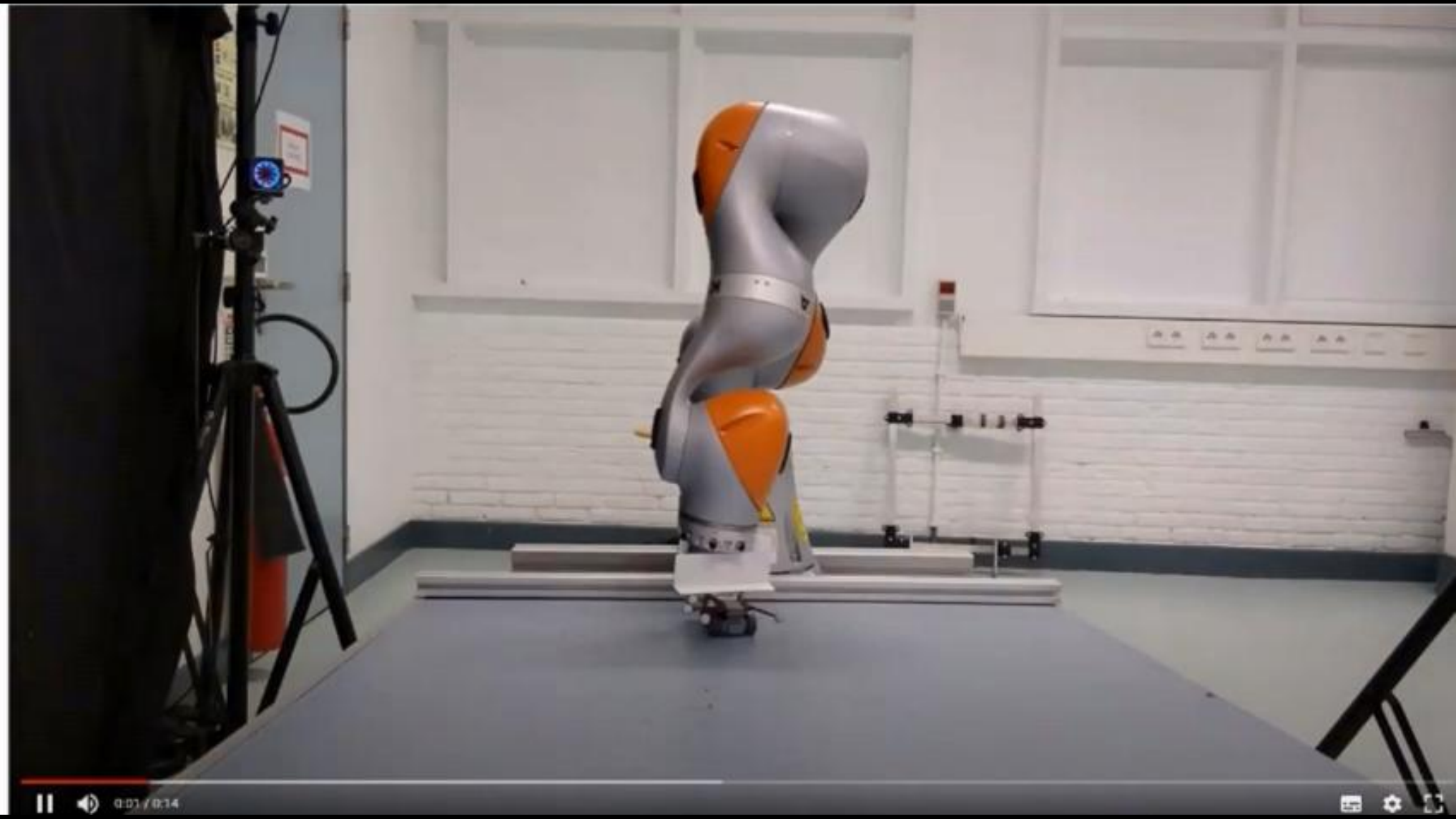
2x



Celemin & Kober, NCA 2023

After learning

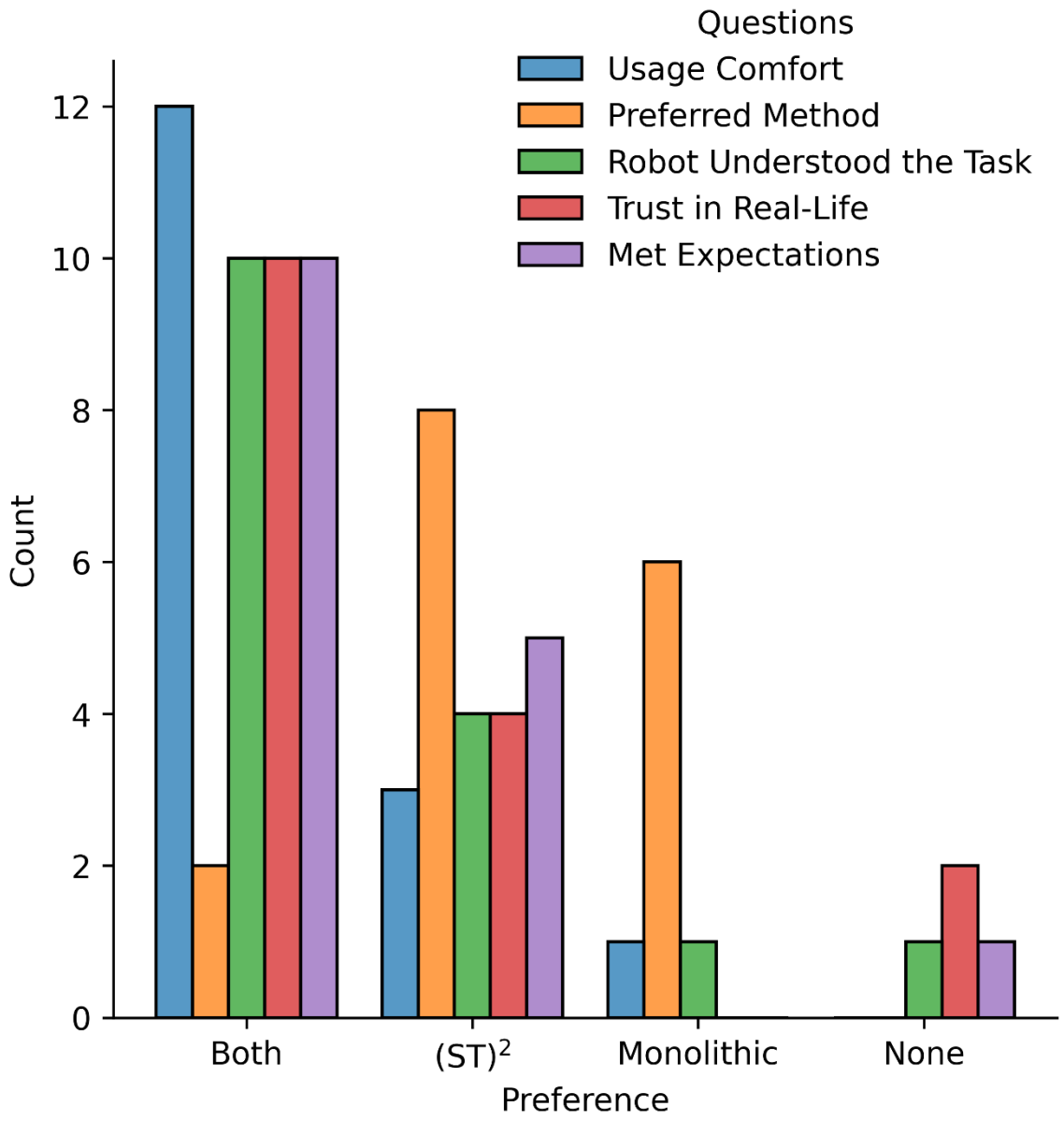
2x



Celemin & Kober, NCA 2023

Ajanović et al., RAM 2025

Wide Variability



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Ajanović et al., RAM 2025

WINNER: 2024 euROBIN Manipulation Skill Versatility Challenge

Team Platonics: Franzese, Ramirez, Spahn

Conclusion

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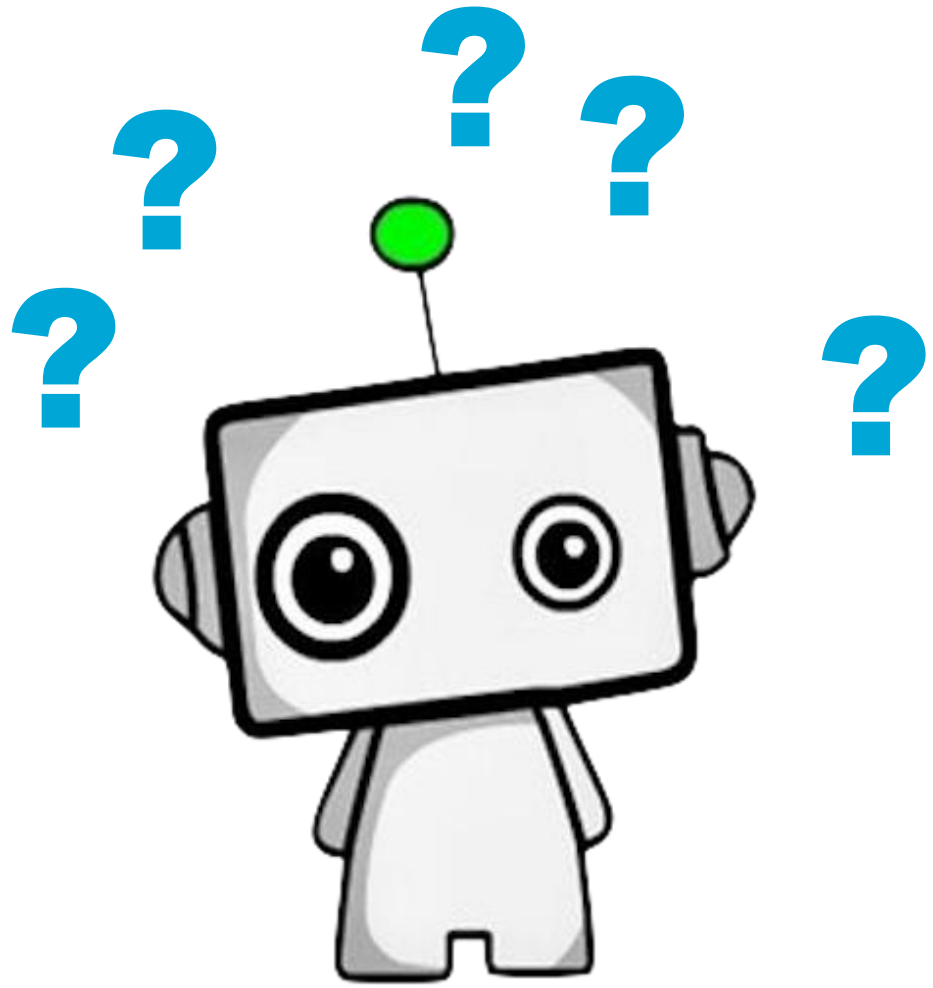
and even more challenges…

- 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?

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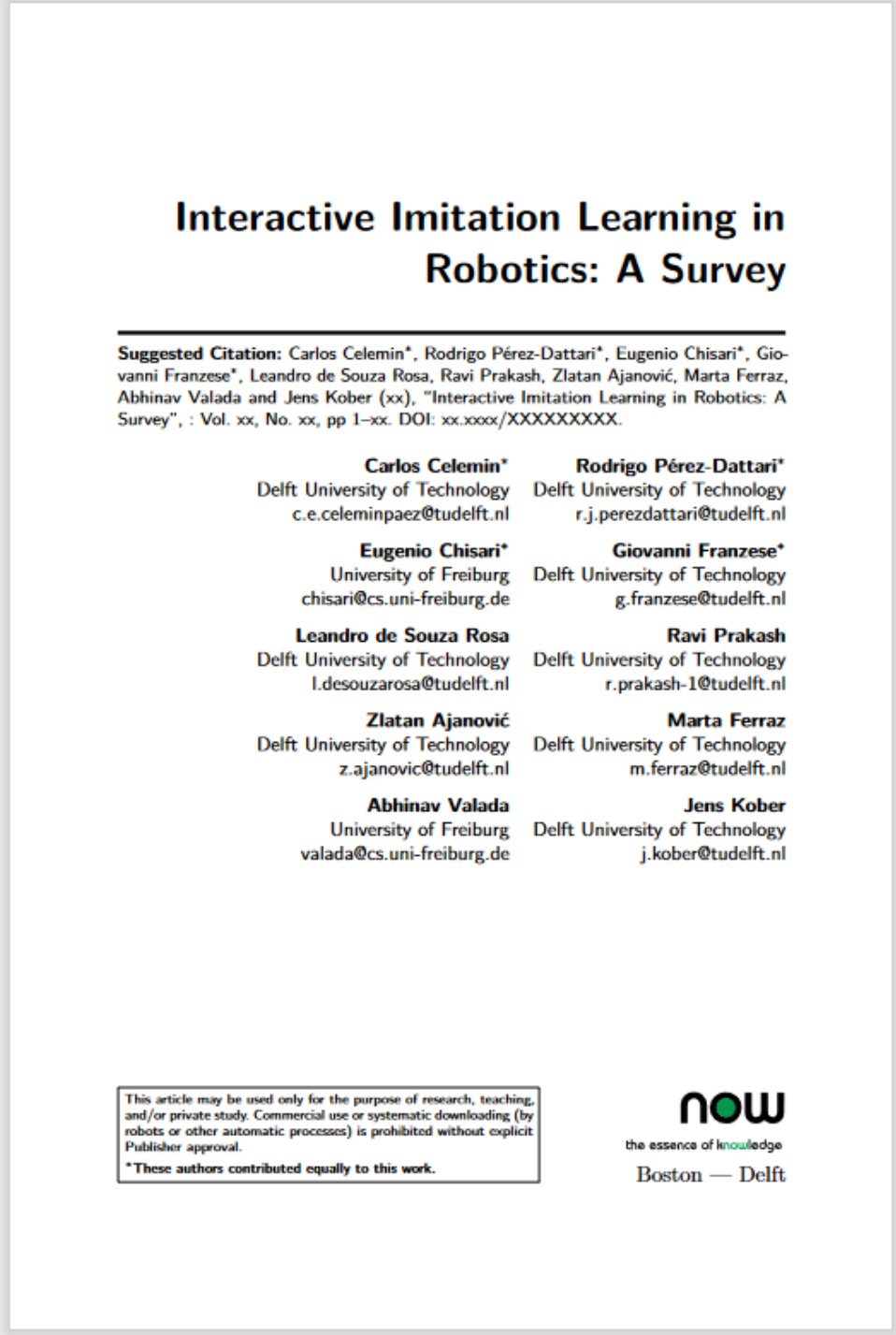

Interactive Imitation Learning in Robotics: A Survey

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/XXXXXXXXX.

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Thank You!

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