Robot Learning & Interaction

Research Programs

Human-AI Teaming
AI for Life

AI for Sustainable & Resilient Societies
AI for Everyone

MARTIGNY

SUISSE
Allemagne
France
Autriche
Italie
VALAIS

Idiap's 3 missions:
- Research
- Education
- Technology transfer

Joint development plan with:

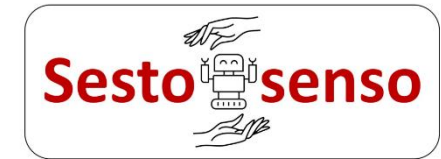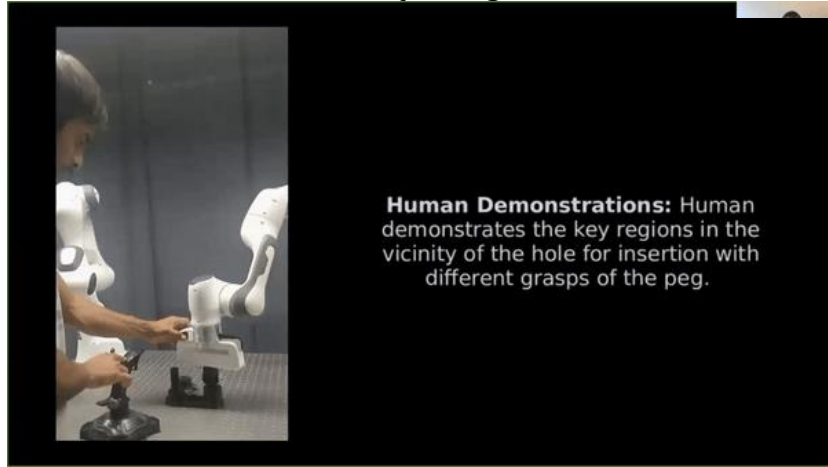ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Application 1: Insertion

Sensorless peg-in-hole insertion

Suhan Shetty

Reference Distribution

Ergodic Control → Dynamic System

Distribution Matching

Insertion using Ergodic Exploration

https://www.thespruce.com/

[Shetty, Silvério and Calinon, IEEE Trans. on Robotics, 2022]
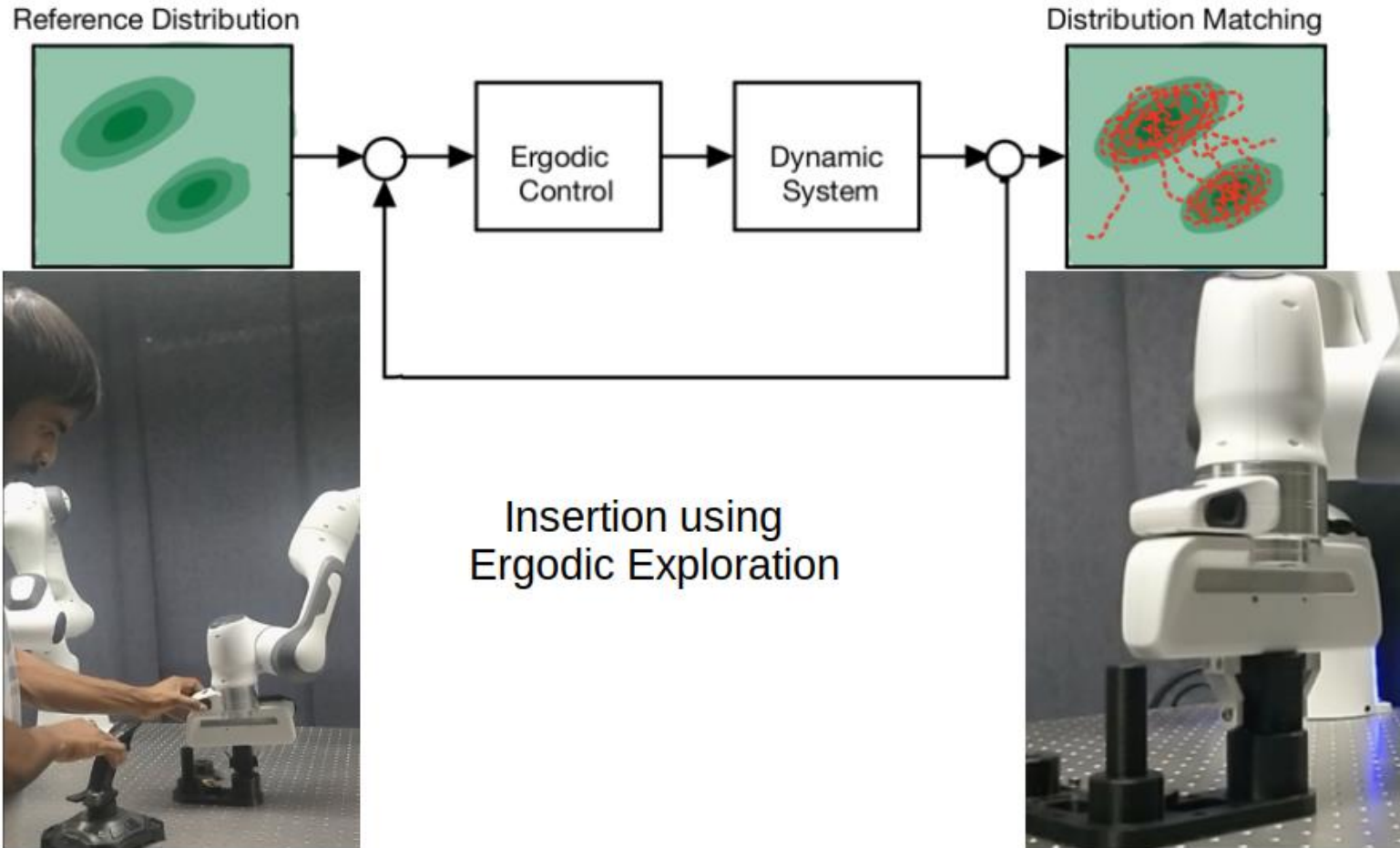
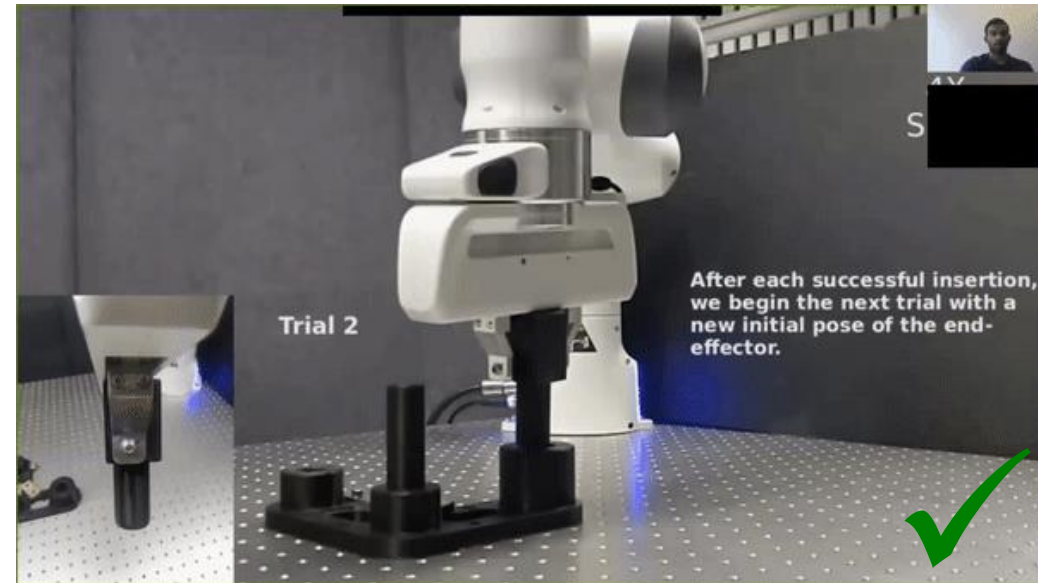# Sensorless peg-in-hole insertion

Suhan Shetty

Collect Demonstration

Position   Orientation
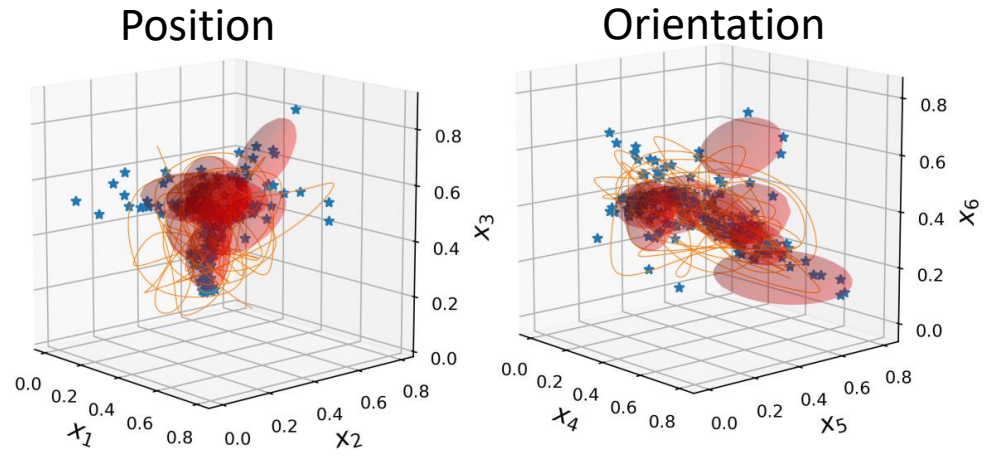
Model Reference Distribution (6D)
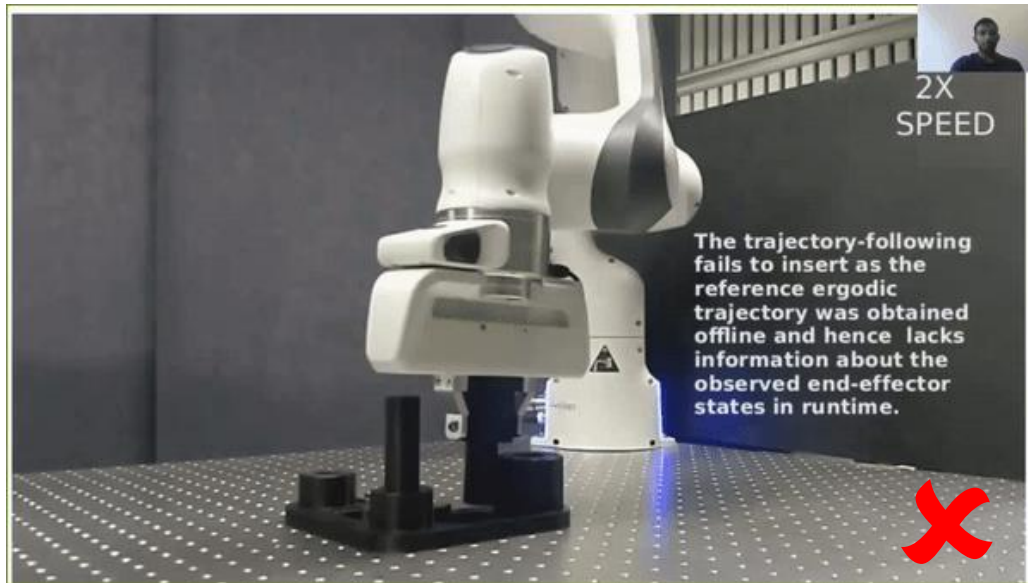
Open Loop Ergodic Control

Closed Loop Ergodic Control

[Shetty, Silvério and Calinon, IEEE Trans. on Robotics, 2022]

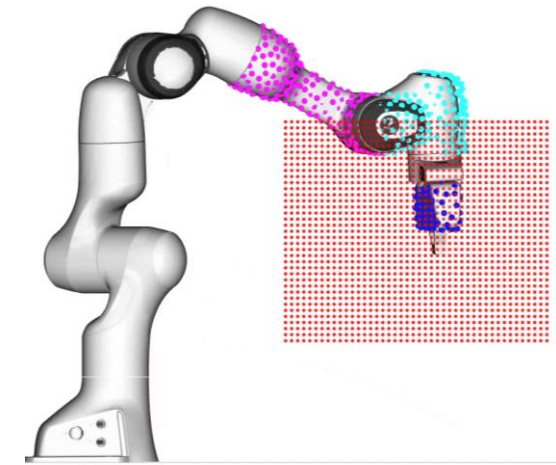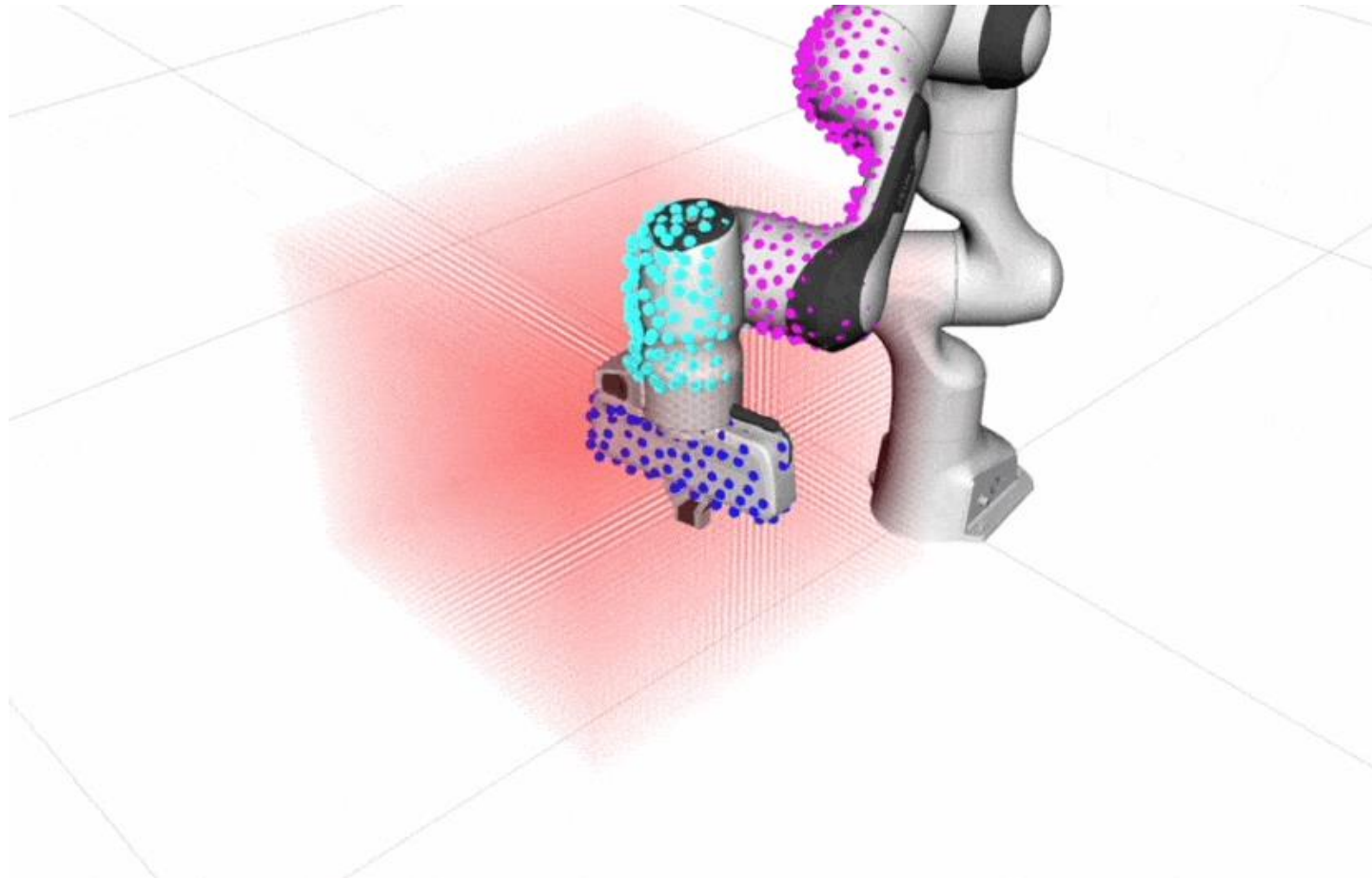# Application 2: Whole-body exploration

Ergodic control for whole body exploration

Cem Bilaloglu   Tobias Löw

Increased sensor footprint by modelling the whole-body as a collection of virtual exploration agents

Locally consistent exploration by non-stationary diffusion

[Bilaloglu, Löw and Calinon, IEEE RA-L, 2023]
ThAT18.07 (10:30-12:00) @ ICRA

Ergodic control based on diffusion

Cem Bilaloglu

Tobias Löw

Heat Equation Driven Area Coverage (HEDAC)

[Ivić, Crnković, & Mezić, IEEE Transactions on Cybernetics, 2017]
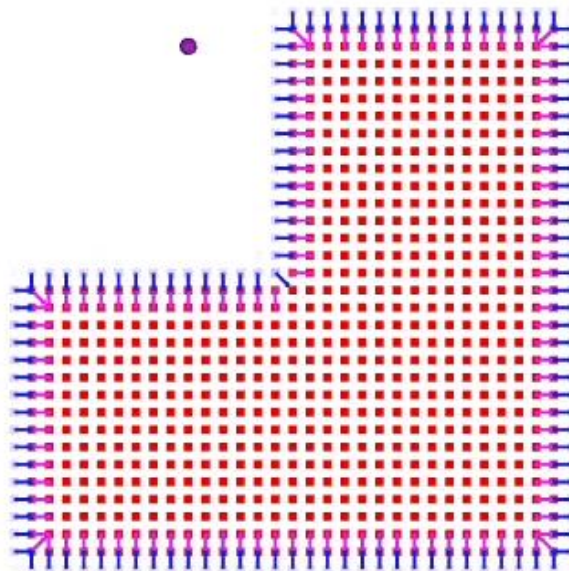
Diffusion equation

$$\dot{u}(\boldsymbol{x}, t) = \alpha \cdot \Delta u(\boldsymbol{x}, t) + s(\boldsymbol{x}, t)$$

$$s(\boldsymbol{x}, t) = d(\boldsymbol{x}) - c(\boldsymbol{x}, t)$$

$$\nabla u(\boldsymbol{x}, t)$$

[Bilaloglu, Löw and Calinon, IEEE RA-L, 2023]
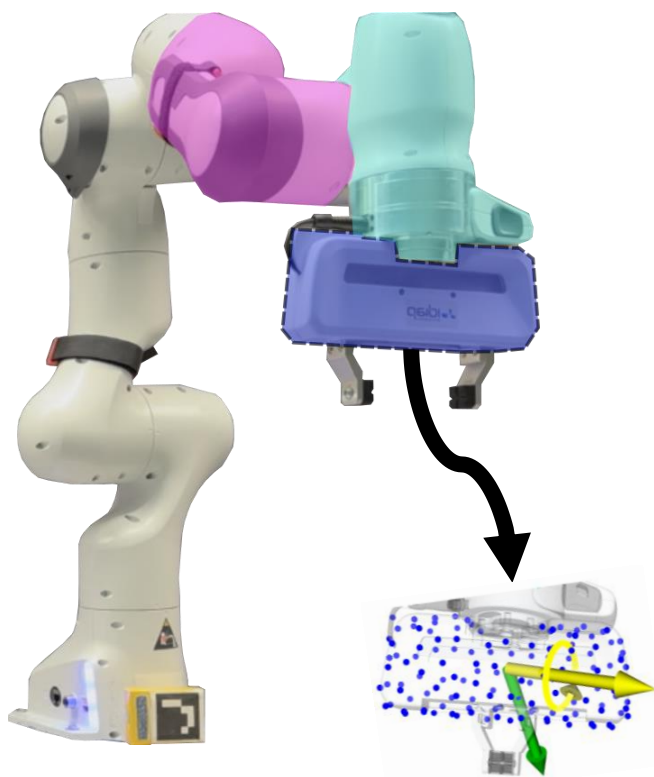
ThAT18.07 (10:30-12:00) @ ICRA

Global exploration with local consistency
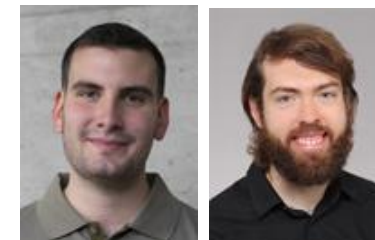
Cem Bilaloglu
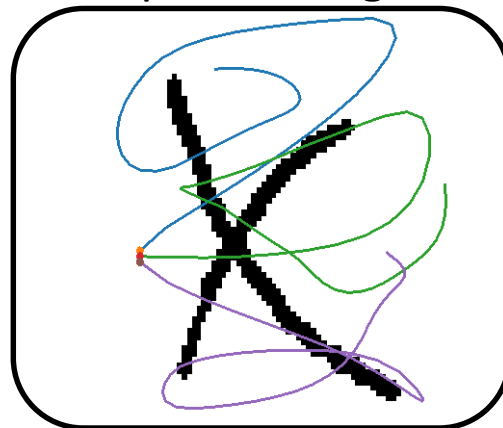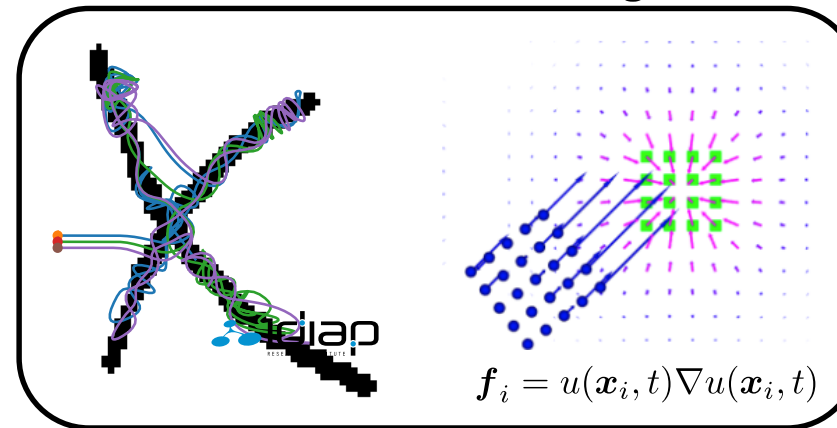
Tobias Löw

Decompose whole body into a set of agents

Independent agents

Consensus between agents

$$\boldsymbol{f}_i = u(\boldsymbol{x}_i, t)\nabla u(\boldsymbol{x}_i, t)$$

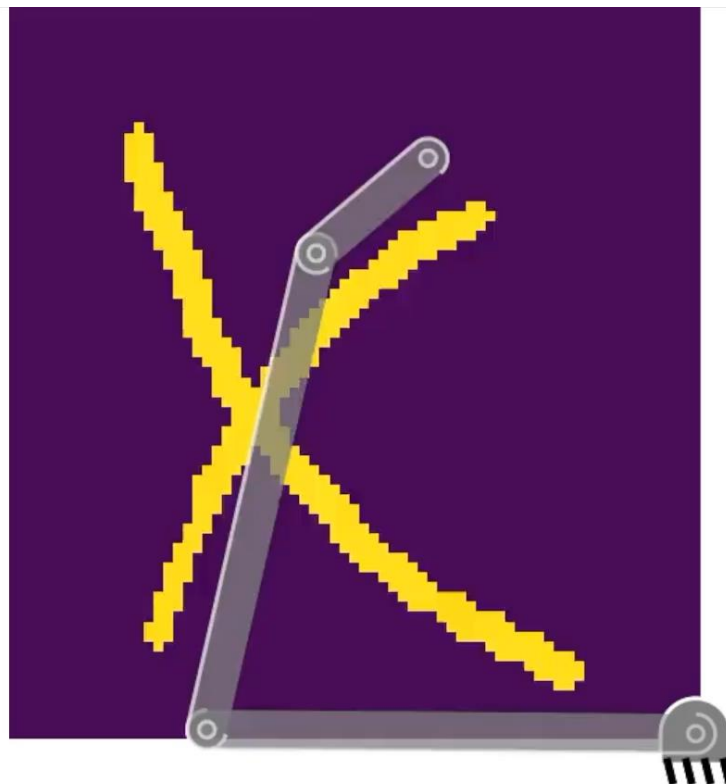smooth vector field
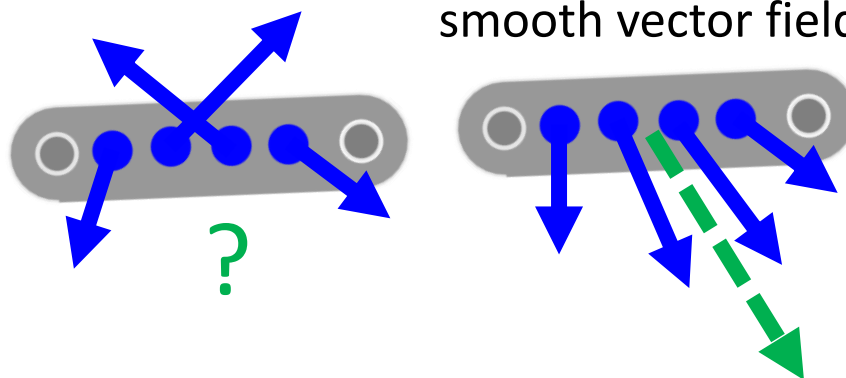
?

ThAT18.07 (10:30-12:00) @ ICRA
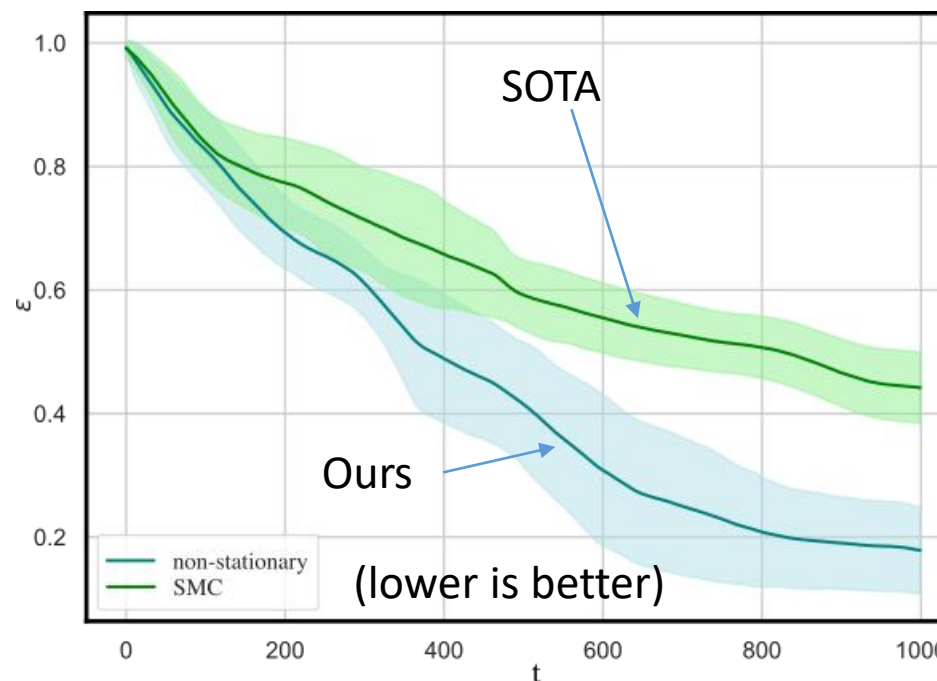
Ergodic control for whole body exploration

Cem
Bilaloglu

Tobias
Löw

We measure the performance using

$\varepsilon = \text{unexplored region/target region}$

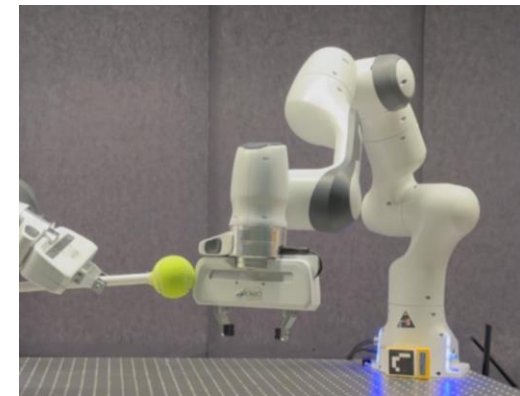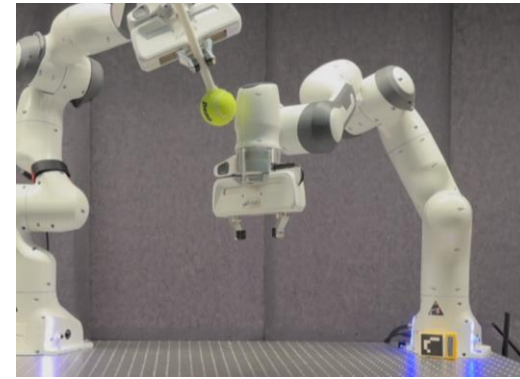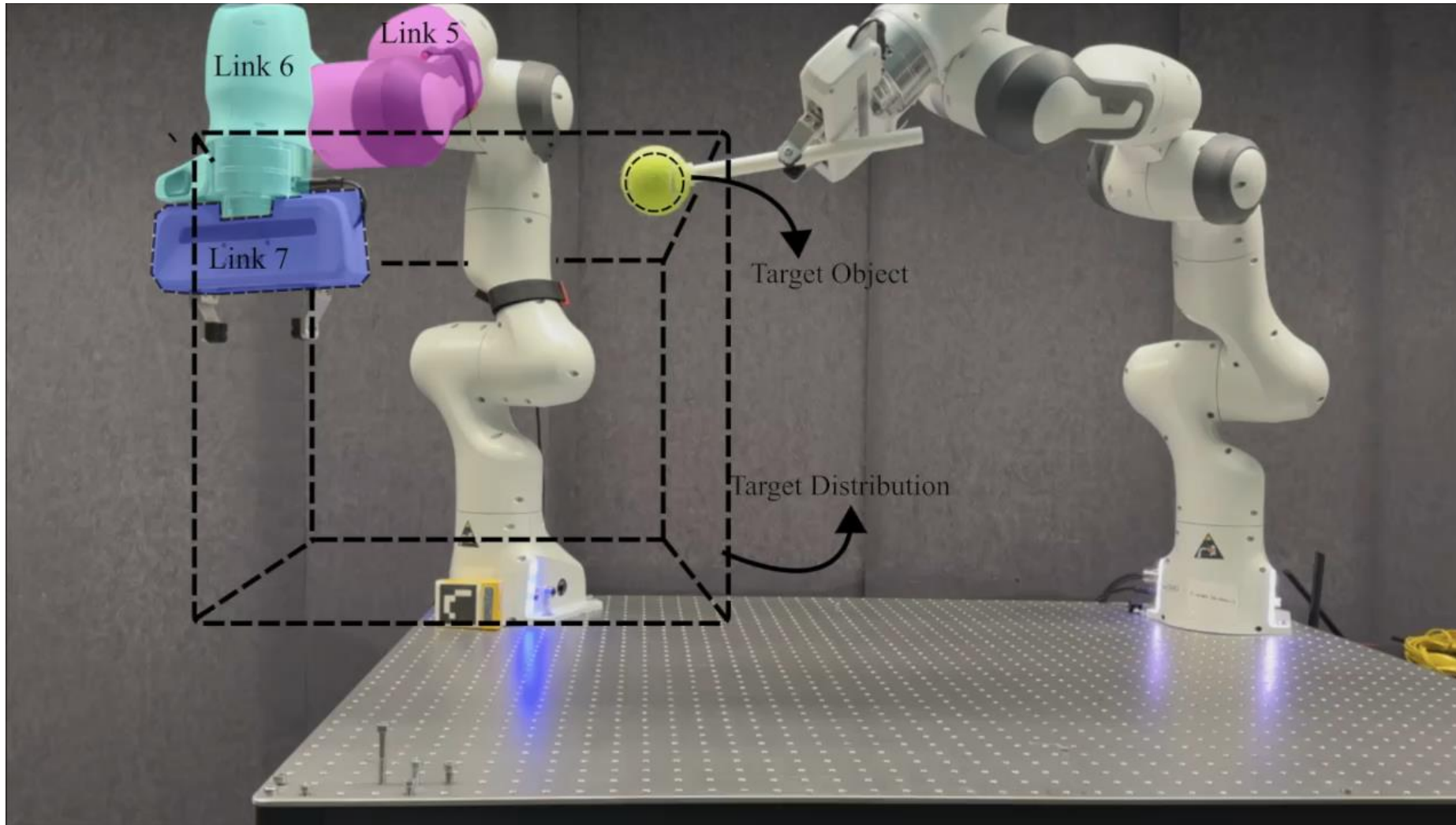$= \|\max(s(\boldsymbol{x}, t), 0)\|_2 / \int_{\Omega} d(\boldsymbol{x}) d\boldsymbol{x}$

SOTA

Ours

(lower is better)

— non-stationary
— SMC

[Bilaloglu, Löw and Calinon, IEEE RA-L, 2023]

ThAT18.07 (10:30-12:00) @ ICRA

Ergodic control for whole body exploration
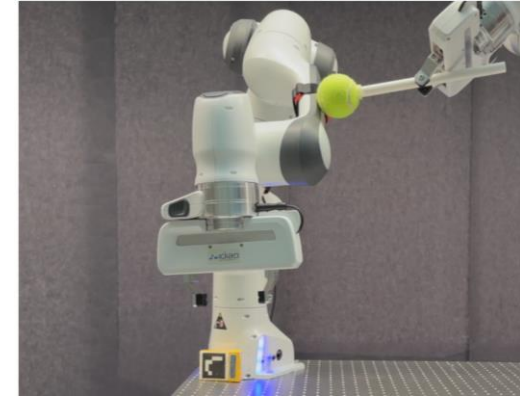
Explore the region until contact, using links 5, 6, 7

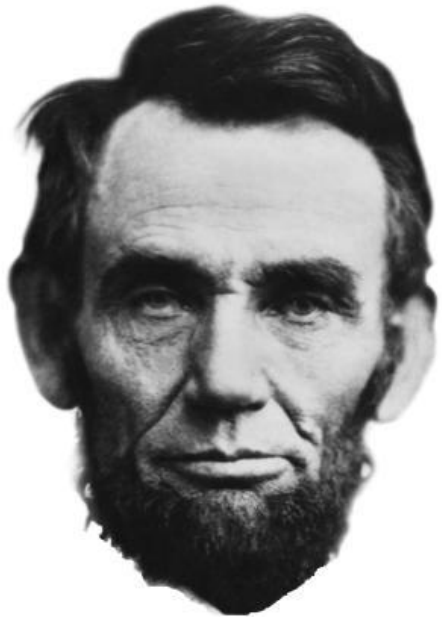**ThAT18.07 (10:30-12:00) @ ICRA**

Application 3: Drawing

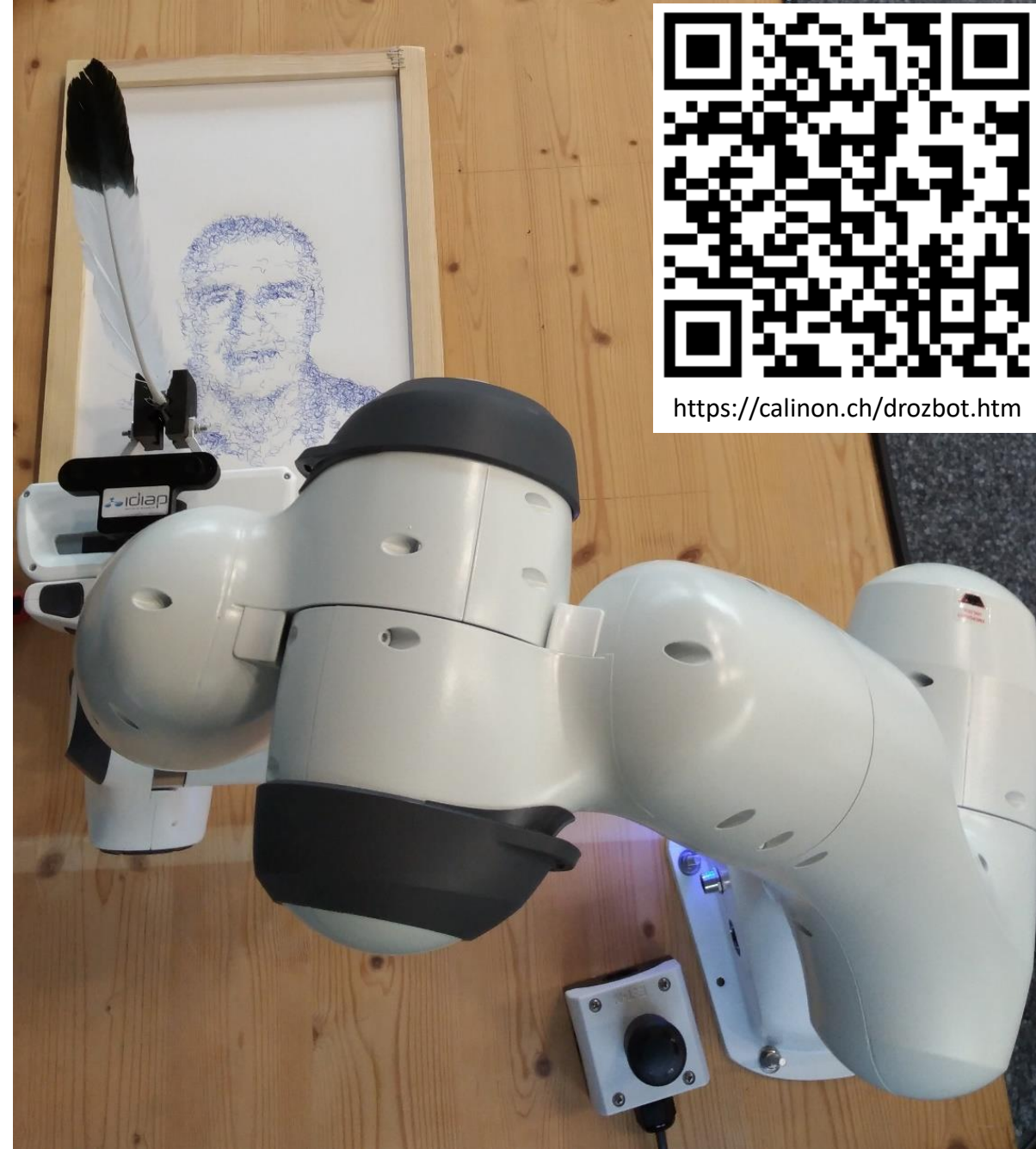# DrozBot: The portraitist robot

Tobias
Löw

HEDAC
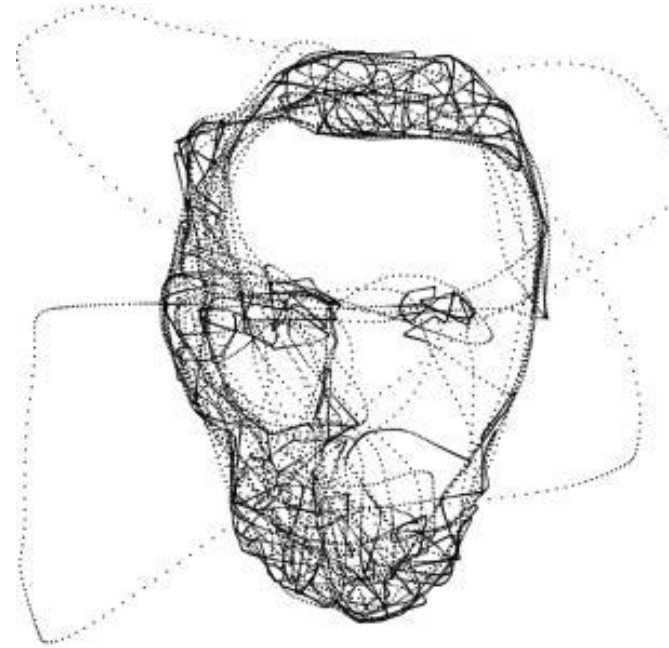
SMC

Stochastic

[Löw, Maceiras and Calinon, IEEE RA-L, 2022]

DrozBot: The portraitist robot

Tobias Löw

https://www.museedelamain.ch

[Löw, Maceiras and Calinon, IEEE RA-L, 2022]

DrozBot: The portraitist robot

https://calinon.ch/drozbot.htm

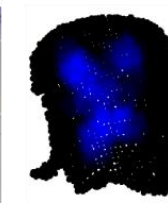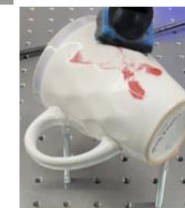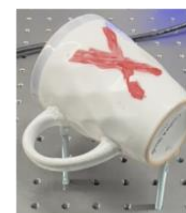[Löw, Maceiras and Calinon, IEEE RA-L, 2022]
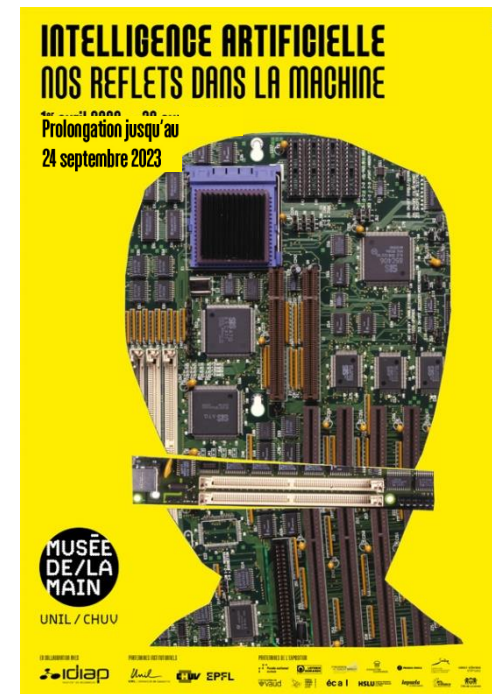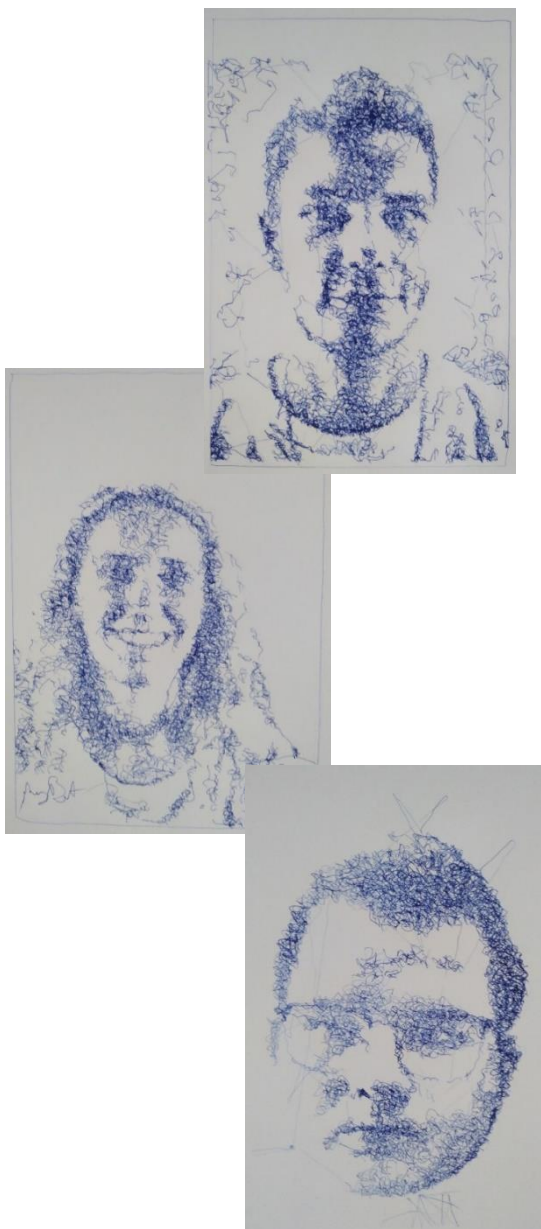
Application 4: Washing

Ergodic control on point clouds

Closed-loop surface exploration using ergodic control:

- Exploration domain is a point cloud
- Can handle targets and obstacles
- Use of proximity or tactile sensors
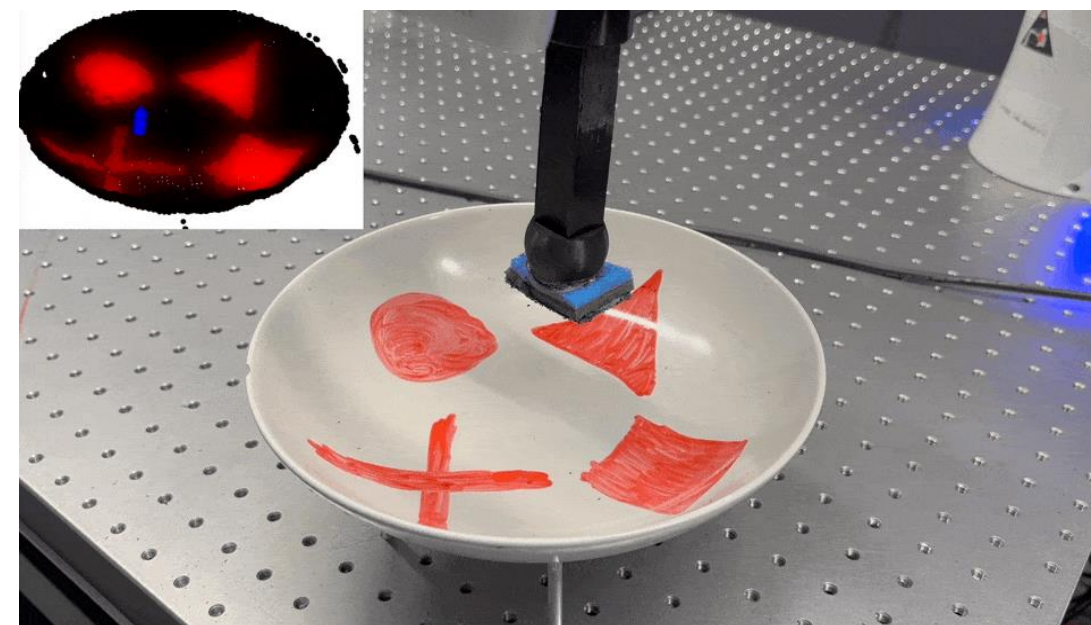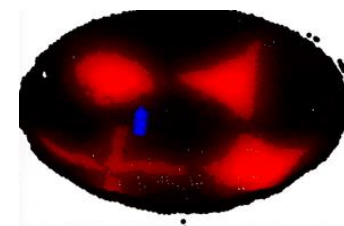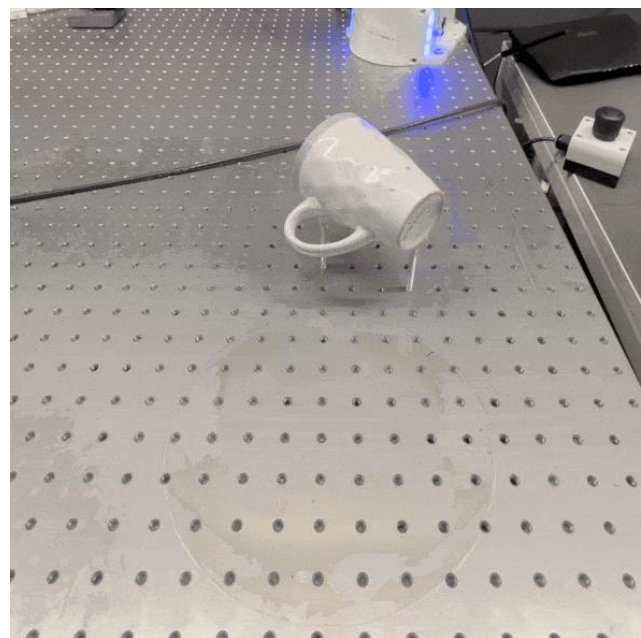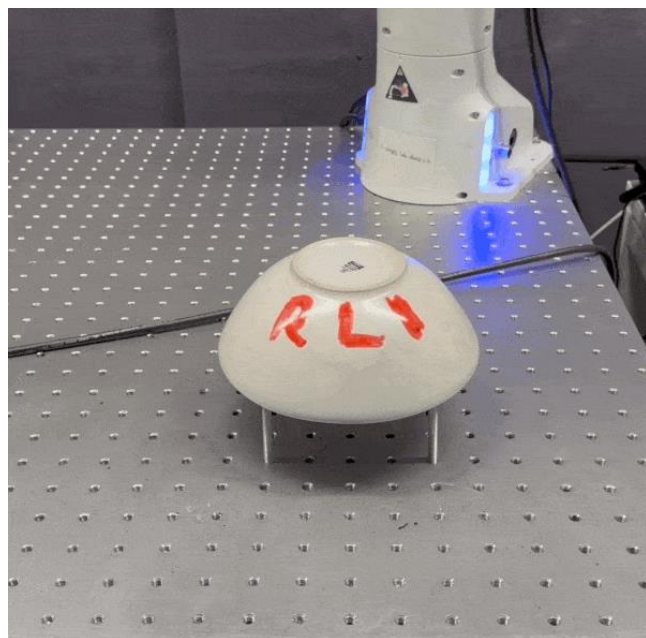- Combining local and global exploration

Cem Bilaloglu

Tobias Löw

Webpage: bit.ly/tactile_control

[Bilaloglu, Löw and Calinon, arXiv:2402.04862, 2024]

Ergodic control on point clouds

Cem
Bilaloglu

Tobias
Löw

Constraint   Target   Point Cloud

$\dot{u} = \Delta u$

$\dot{x} = (u_{\max} - u(x))\nabla_x u$

Gradient Field

Potential Field

[Bilaloglu, Löw and Calinon, arXiv:2402.04862, 2024]