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Sequential Robotic Task Learning From Demonstrations

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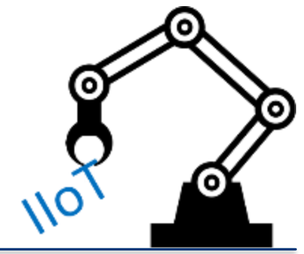
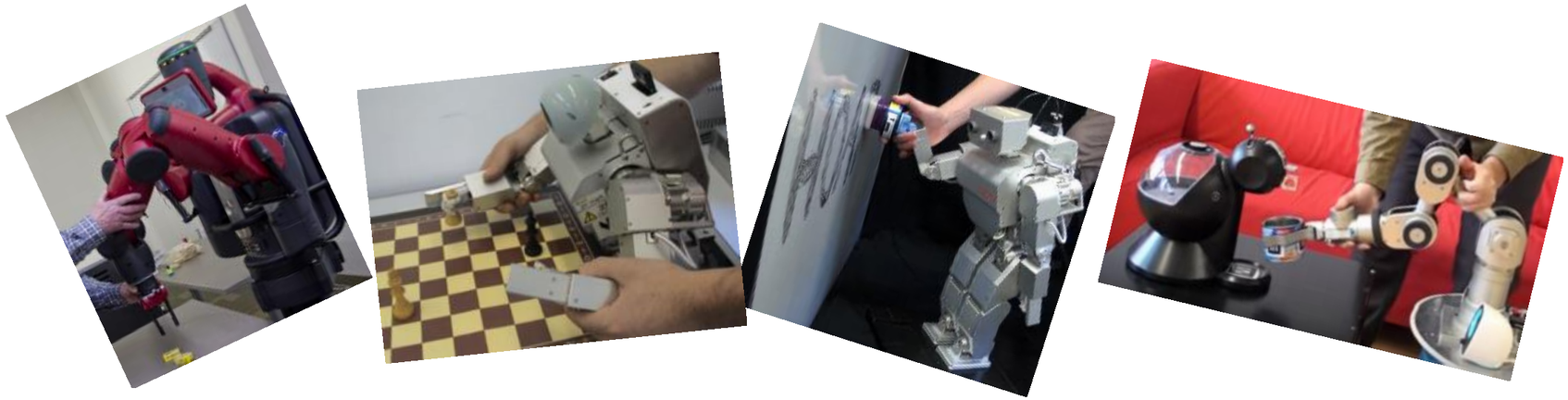


Project Objective

- Learning from Demonstrations (LfD)

A lay user demonstrates the task/ a concept ⟺ **The robot observes, asks 'good' questions and learn**



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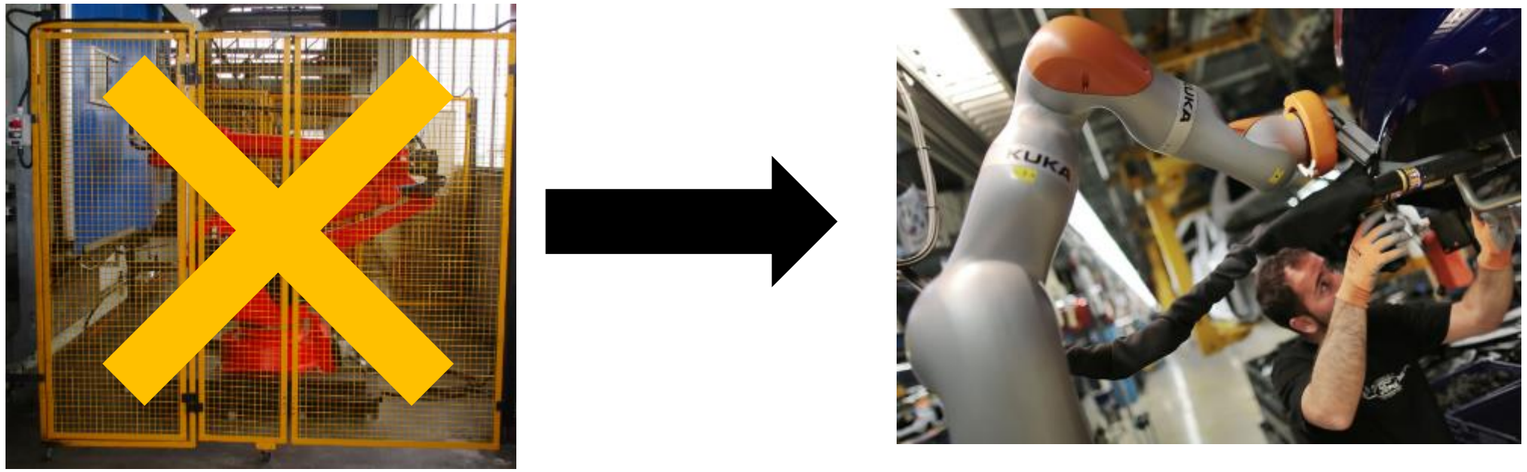
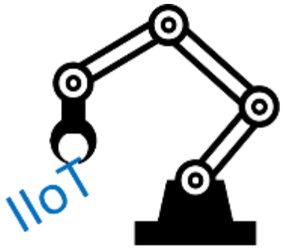
Industrial Need and Relevance

- What does that mean for Industries?

Collaborative Robots (Cobots)



Industrial Need and Relevance



- How do you teach a cobot a new task?

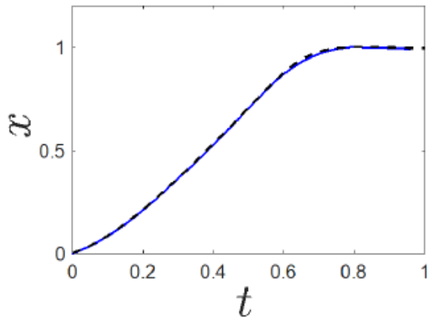
Robust learning of sequential task using a dynamic systems based approach

Phase space transition function (PSTF)

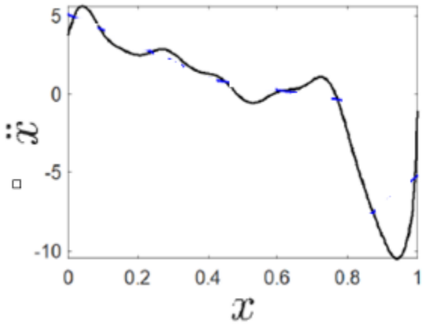
A second order conservative dynamic system that always reaches a phase space state (position, velocity) from a given initial state

Approach/Methodology

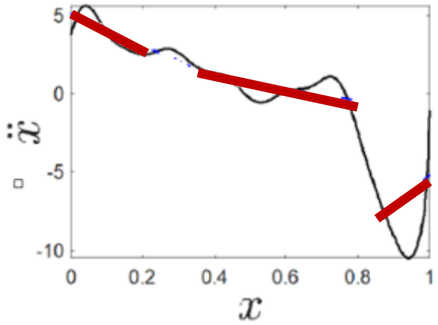
- PSTF based approximation of task trajectory



Demonstrated trajectory



$\ddot{x} - x$ projection of the Phase Space Curve (PSC)



$PSTFs$ approximating the PSC

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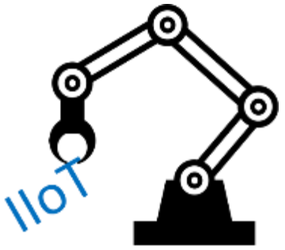
Approach/Methodology



$$\ddot{x} = \begin{cases} k_n x + c_n - T\dot{x}(t_E - t_e) & \dot{x} \geq \frac{x_n - x_c}{|x_n - x_c|} \\ m & \dot{x} < \frac{x_n - x_c}{|x_n - x_c|} \\ \frac{-\dot{x}_c^2}{2(x_{ob} - x_c)} & CD \end{cases}$$

k_n: The slope of the n-th PSTF ; c_n: A constant that satisfies the velocity boundary condition
T: A time interval, currently hand picked for DOF synchronization
$x_c, \dot{x}_c$: Position and velocity at the Current time; m: A constant acceleration
t_E: The time to execute one DOF of the trajectory
CD: a flag signaling obstacle on the planned trajectory

Ref: Paul Gesel, M. Begum, D. LaRoche, Learning Motion Trajectories from Phase Space Analysis of the Demonstrations, submitted to ICRA 2019

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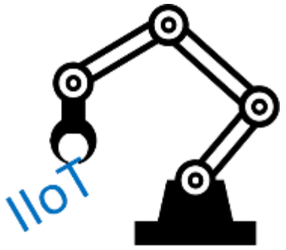
Approach/Methodology



- PSTFs are determined in such a way that the demonstrated trajectory
  - ✓ is accurately reproduced
  - ✓ is stable
  - ✓ can be adapted to new goal and start positions
  - ✓ can avoid unplanned obstacle
  - ✓ can synchronize multiple DOFs under perturbation