Karlsruhe Institute of Technology

Autonomous Learning Robots (ALR)
Prof. Gerhard Neumann

Project Type

- ☑ Master Thesis
- ☐ Bachelor Thesis
- ☑ Research Project

Supervisors

☞ Philipp Becker
@ philipp.becker@kit.edu

Difficulty

Algorithmic

Math

Application

Model-Based RL for Challenging Manipulation Tasks

Description

Recent work showed that modern model-based reinforcement learning approaches can be deployed on real robots for simple manipulation tasks [3]. Yet, the considered tasks are conceptually simple, using highly discretized action spaces and low-frequency control and observation frequencies. While this is feasible for some tasks, like grasping single soft objects, many interesting settings are more challenging. They require more precise, continuous control, working on a higher frequency, as well as considering forces and torques.

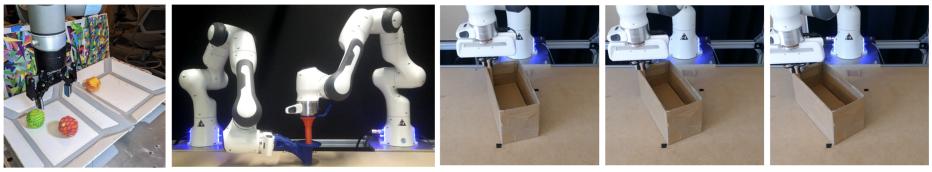

Figure 1: While Model-Based Reinforcement Learning on real robots was previously used for simple tasks where highly discretized action spaces and low-frequency observations are sufficient (e.g., picking up soft items, as on the left), here we are going to look at how to make it work for more challenging tasks. A first example is plugging an electrical plug into a power socket (middle). As the plug occludes the socket we cannot rely on vision but need to consider forces applied to the robot. A second example is a box manipulation task (3 images on the right). The challenge here is that the robot constantly needs to react to the box's movement which might not be entirely predictable due to unknowns such as friction or the box's weight.

This thesis aims at investigating the use of model-based RL for more challenging tasks. We will have a look at the preconditions for such tasks, how to represent the actions, and how to incorporate information from various sensors at differing frequencies.

Tasks

- Getting familiar with recent model-based RL approaches [2, 1] and our simulation pipeline.
- Design challenging manipulation tasks in our simulation framework and evaluate model-based RL approaches on those tasks.
- Investigate different approaches to action representation and observation fusion.
- Work towards deploying the developed methods on a real robot system.

References

[1] Philipp Becker and Gerhard Neumann. On uncertainty in deep state space models for model-based reinforcement learning.

[2] Danijar Hafner, Timothy Lillicrap, Jimmy Ba, and Mohammad Norouzi. Dream to control: Learning behaviors by latent imagination. *arXiv preprint arXiv:1912.01603*, 2019.

[3] Philipp Wu, Alejandro Escontrela, Danijar Hafner, Ken Goldberg, and Pieter Abbeel. Daydreamer: World models for physical robot learning. *arXiv preprint arXiv:2206.14176*, 2022.