Karlsruhe Institute of Technology

Autonome Lernende Roboter (ALR)

Prof. Gerhard Neumann

Project Type

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

Supervisors

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Difficulty

Algorithmic

Math

Application

Inverse Dynamics Learning for Pneumatic Muscular Robots

Description

Robotic arms actuated by antagonistic pneumatic artificial muscle (PAM) pairs incur abilities like fast reaction times along with robustness. These abilities are critical for solving uncertain, high-dimensional and fast-changing tasks. However such systems are challenging from a control point of view due to non-linearities, time-varying behavior as well as hysteresis effects. Recent work[3] has shown promising results in learning the forward dynamics of these robots. However learning the inverse dynamics which is important for control remains unsolved because of the one-to-many mapping functions that need to be learnt in addition to the previously mentioned challenges. This thesis will explore ways to overcome this challenge by using an action decoder that is inherently mutlimodal, design of which will form the algorthmic contribution. Experiments will be conducted on simulations as well as real robots.

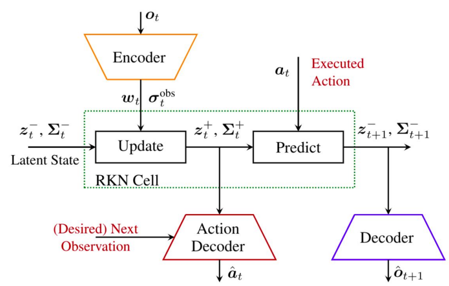

Figure 1: Left: Schematic Of AcRKN[3]. Right: Musculoskeltal Robot Arm playing Table Tennis[1].

Tasks

The tasks in this project will include:

- Literature Review: Getting familiar with AcRKN Inverse Dynamics Learning architecture and existing literature on real time robot control with inverse dynamics learning. Explore current literature for inverse dynamics learning of pneumatic arm and one-to-many regression approaches.
- Phase 1 Experiments: You will first implement the existing architecture on a robot(simulation/real) with simple dynamics like Franka from ALR Lab in the first Phase and analyze the performance for real time control.
- Phase 1 Algorthmic Modification For AcRKN: You will modify the existing architecture using deep learning frameworks to address the one-to-many mapping issue. A starting point will be to use mixture networks as action decoder. The results would be evaluated on offline data from the PAM robot[2].
- Phase 2 Experiments: Once a suitable architecture is designed, use it for real time control of PAM on simulations/real robot.

References

[1] Dieter Büchler, Simon Guist, Roberto Calandra, Vincent Berenz, Bernhard Schölkopf, and Jan Peters. Learning to play table tennis from scratch using muscular robots. *arXiv preprint arXiv:2006.05935*, 2020.

[2] Dieter Büchler, Heiko Ott, and Jan Peters. A lightweight robotic arm with pneumatic muscles for robot learning. In *2016 IEEE International Conference on Robotics and Automation (ICRA)*, pages 4086–4092. IEEE, 2016.

[3] Vaisakh Shaj, Philipp Becker, Dieter Buchler, Harit Pandya, Niels van Duijkeren, C James Taylor, Marc Hanheide, and Gerhard Neumann. Action-conditional recurrent kalman networks for forward and inverse dynamics learning. *arXiv preprint arXiv:2010.10201*, 2020.