Karlsruhe Institute of Technology

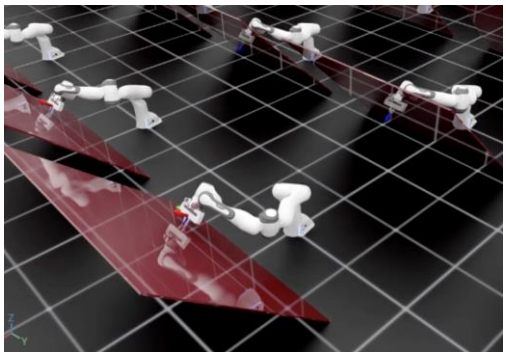
Machine Intelligence and Robotics Lab

Bachelor Thesis – Learning Admittance Control with Implicit Force Estimation

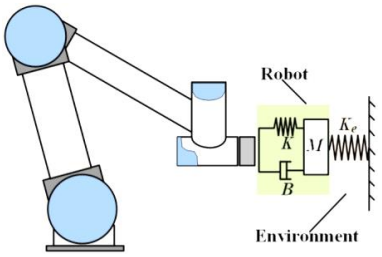
Reinforcement Learning (RL) has shown strong results in robotics, yet contact-rich tasks still require precise force control. Classical admittance controllers often suffer from tracking errors due to model inaccuracies and are difficult to transfer between simulation and real systems. This motivates learning-based approaches for more accurate interaction and reduced sim-to-real gap.

Research Area and Background

Interaction with the environment is unavoidable in many manipulation tasks, making force-based control essential. Classical admittance controllers can track Cartesian forces but suffer from model inaccuracies, leading to tracking errors and sim-to-real inconsistencies. This motivates learning-based approaches that model interaction behavior and support training of higher-level force-based skills (e.g. insertion). A key challenge is to estimate interaction forces from past observations without force/torque sensors, either explicitly or through learned representations.



NVIDIA Isaac Lab. "Operational Space Controller Example." Isaac Lab Documentation,https://isaacsim.github.io/IsaacLab/main/source/tutorials/05_controllers/run_osc.html.



Li, Zhisen, et al. "A fuzzy adaptive admittance controller for force tracking in an uncertain contact environment." IET control theory & applications 15.17 (2021): 2158-2170.

Your Tasks and Research Challenges

- **Literature research on state of the art**
  - Admittance and force control
  - RL control with force estimation
- **Development and Implementation**
  - Develop an RL environment for Admittance control
  - Define different force estimator solutions
- **Evaluation and Documentation**
  - Compare your policies/estimators in simulation
  - Evaluate and summarize your results in a thesis

What we offer at the Machine Intelligence and Robotics Lab!

- You'll get to learn a lot about our current research and gain some real hands-on experience
- We use the latest robotics hardware and the newest ML libraries, as well as tools like Isaac Lab, ROS 2, etc.
- We are a team of international, motivated robotics enthusiasts and would be happy to have you join us.
- You will get encouraging support from your supervisor and honest feedback to improve your skills
- We offer a great working environment in our MaiRo Lab

Type: **Bachelor thesis**

Date: **As soon as possible**

Supervisors: **Prof. Dr. Arne Rönnau, M. Sc. Vincenzo Di Pentima**

Do you want to work on cutting edge robotics research?

Contact: Vincenzo Di Pentima, vincenzo.pentima@kit.edu

We look forward to receiving your application (incl. current grade transcript)!

Karlsruhe Institute of Technology

Machine Intelligence and Robotics Lab

Master Thesis – Learning Admittance Control with Implicit Force Estimation

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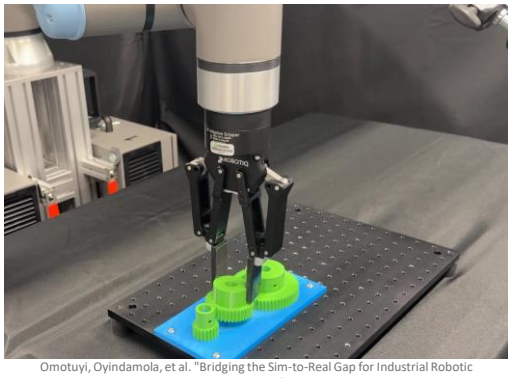
Research Area and Background

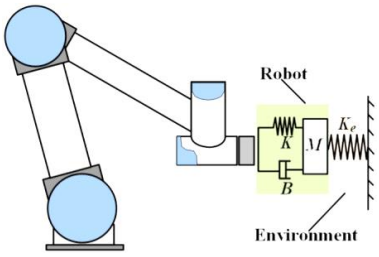
Interaction with the environment is unavoidable in many manipulation tasks, making force-based control essential. Classical admittance controllers can track Cartesian forces but suffer from model inaccuracies, leading to tracking errors and sim-to-real inconsistencies. This motivates learning-based approaches that model interaction behavior and support training of higher-level force-based skills (e.g. insertion). A key challenge is to estimate interaction forces from past observations without force/torque sensors, either explicitly or through learned representations.



Omotuyi, Oyindamola, et al. "Bridging the Sim-to-Real Gap for Industrial Robotic Assembly Applications Using NVIDIA Isaac Lab." NVIDIA Technical Blog, 20 May 2025, https://developer.nvidia.com/blog/bridging-the-sim-to-real-gap-for-industrial-robotic-assembly-applications-using-nvidia-isaac-lab/.

Your Tasks and Research Challenges

- **Literature research on state of the art**
  - Admittance and force control
  - RL control with force estimation
- **Development and Implementation**
  - Develop an RL environment for Admittance control
  - Define different force estimator solutions
- **Evaluation and Documentation**
  - Deploy and compare your policies/estimators on a real robot
  - Use policy as low-level controller for force-based skills
  - Evaluate and summarize your results in a thesis



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