Optimization and Biomechanics for Human Centred Robotics
KIT BioRobotics Lab

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Master's Thesis:
RL Sim2Real Study for Walking Motions with the Humanoid Robot H1

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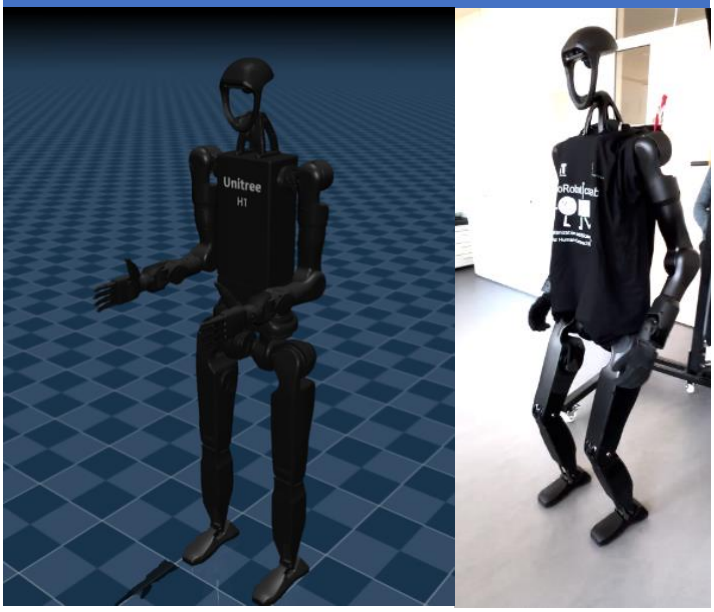
Background

Over the past years, Reinforcement Learning (RL) has become a very popular approach for generating motions and control strategies for humanoid robots, particularly in bipedal locomotion. However, due to the very time consuming trial-and-error processes involved and the damages involved with real robots failing and falling, the training only takes place in the simulator and not on the real robot. This requires very precise models of the humanoid robot, but even with the best models will introduce a reality gap that will compromise performance when transferred to the real robot. Various methods have been proposed in the literature for improving the Sim2Real transfer, but only few validations on real robots have been performed [1].

H1-2 robot – Model & real robot @ KIT BioRobotics Lab



Scope of the thesis

The objective of this Master's thesis is to investigate Simulation-based RL and subsequent Sim2Real approaches for humanoid walking motions at the example of the bipedal humanoid robot H1-2 by Unitree, which we recently received in our lab. The scope of this thesis includes:

- Literature research on RL and Sim2Real for humanoid walking motions
- Evaluating existing implementations of H1-2 models for physical consistency, and of different RL training environments
- Formulating new locomotion task examples and generating solutions using simulation based RL
- Evaluating different Sim2Real transfer approaches, including dynamics randomization, introduction of noise/delay, introduction of perturbations, etc. following inspiration from the paper [1] where this task is performed for a different humanoid robot (TOCABI)
- Performing experiments with the real H1-2 robot, recording the resulting motions for the chosen locomotion tasks and evaluating the resulting reality gaps / performance drops

Required knowledge

This thesis requires understanding of mechanical and robotics concepts (Robotics 1 or similar), knowledge of machine learning concepts, and ROS2 and programming knowledge.

[1] D Kim, H Lee, J Cha and J Park – Bridging the Reality Gap - Analyzing Sim-to-Real TransferTechniques for Reinforcement Learning in Humanoid Bipedal Locomotion, Robotics and Automation Magazine, March 2025