Luis Scheuch | 2024-11

Projektarbeit HULKs | Exposé

Working title: Creating a Virtual NAO Robot Model for Reinforcement Learning: Enabling Advanced Motion Algorithms for the HULKs and the RoboCup Community.

1. Introduction
   - Background: The HULKs are the RoboCup SPL team of the Hamburg University of Technology. We are programming robots in Rust to autonomously play soccer. Currently, all motion-related tasks, such as standing up, walking, kicking, etc. are classical algorithms or hand-tuned keyframe animations. Tuning these is an error-prone and time-consuming task.
   - Problem Statement: New methods from reinforcement learning (RL) could be used to improve the motion of the robots. However, the current, unmaintained simulation framework does not provide the means to simulate the motor dynamics and system behavior of the robots and the performance, which is necessary for RL.
   - Objectives: Compare existing simulation frameworks, identify the requirements for a simulation framework for the HULKs, identify key parameters to succeed in Sim2Real and develop a prototype for a virtual NAO robot model that can be used for further RL research. If time permits, implement a simple RL algorithm to demonstrate the capabilities of the simulation framework and the model built.
2. Significance and Impact
   - Currently, there is no implementation of a NAO model which is appropriate for reinforcement learning research. This research could fill this gap and provide a valuable resource for the RoboCup community.
   - Creating a virtual NAO robot model for reinforcement learning could enable the HULKs to develop more advanced motion algorithms and enable more students to contribute to the project.
3. Timeline
   - Literature Review: 60h
   - Simulation Framework Requirements: 25h
   - Prototype Development: 50h
   - RL Algorithm Implementation: 25h
   - Evaluation: 20h
4. Excerpt from Available Literature

[1] T. Haarnoja *et al.*, "Learning agile soccer skills for a bipedal robot with deep reinforcement learning," *Science Robotics*, vol. 9, no. 89, Apr. 2024, doi: 10.1126/scirobotics.adi8022.

[2] B. van Marum, A. Shrestha, H. Duan, P. Dugar, J. Dao, and A. Fern, "Revisiting Reward Design and Evaluation for Robust Humanoid Standing and Walking." [Online]. Available: https://arxiv.org/abs/2404.19173

[3] J. Kober, J. Bagnell, and J. Peters, "Reinforcement Learning in Robotics: A Survey," *The International Journal of Robotics Research*, vol. 32, pp. 1238–1274, 2013, doi: 10.1177/0278364913495721.

[4] J. Hwangbo *et al.*, "Learning agile and dynamic motor skills for legged robots," *Science Robotics*, vol. 4, no. 26, Jan. 2019, doi: 10.1126/scirobotics.aau5872.

[5] J. Siekmann, K. Green, J. Warila, A. Fern, and J. Hurst, "Blind Bipedal Stair Traversal via Sim-to-Real Reinforcement Learning." [Online]. Available: https://arxiv.org/abs/2105.08328