Karlsruhe Institute of Technology

Machine Intelligence and Robotics Lab

Enabling Legged Robots for Autonomous Work on Roofs

A Collaborative master's thesis

Advances in reinforcement learning (RL) and robotics are rapidly transforming how autonomous robots perceive, navigate, and interact with the world. These advances enable complex tasks in challenging environments. Nevertheless, large-scale deployment of autonomous mobile robots remains limited, constraining their real-world usefulness. To get robots into new applications, a task and environment driven adaption of quadrupeds is to be investigated in this collaborative master's thesis.

Basic Thesis Concept

The general goal of this thesis is to enable robust and adaptable operation of quadrupedal robots, e.g. Unitree Go2, in inclined roof environments. As this is quite a large task, that will require mechanical as well as control related changes, the thesis is designed as a collaborative thesis in which two students will work on the same topic, but from two different perspectives. Therefore, a cooperative and communicative way of working is crucial.

Optimization of quadruped feet

- **Analyzation of contact mechanics between robot and environment**
  - Define major physical challenges
  - Set measurable performance goals
- **Design and fabrication of actuated feet**
  - Design an adaptable novel foot
  - Integrate additional actuated DoF's
  - Choose sensible materials and manufacturing technologies
  - Manufacture and build the prototype
- **Evaluation and optimization**
  - Evaluate the design on a test rig
  - Measure comparable performance indicators using a motion capture system
  - Optimize foot geometry based on test results

Optimization of Quadruped RL Controller

- **State-of-the-art analysis**
  - Review and compare reinforcement learning approaches for locomotion
  - Identify control specific challenges for quadruped roof walking
- **Controller development in NVIDIA Isaac Lab**
  - Implement locomotion controller
  - Design roof terrains and task-specific reward functions
  - Integrate foot models into simulation
- **Evaluation and optimization**
  - Improve performance using teacher-student, multi-expert and/or sim-to-real approaches
  - Evaluate performance in simulation and on real hardware

Do you want to work on cutting edge robotics research?

Type: Collaborative Master Thesis

Date: As soon as possible

Supervisors: Prof. Dr.-Ing. Arne Rönnau, M.Sc. Björn-Felix Dettmar & M.Sc. Louis Enslin

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We look forward to receive your application (inc. current grade transcript)!