Optimization and Biomechanics for Human Centred Robotics
KIT BioRobotics Lab

Prof. Dr. Katja Mombaur

Endowed Chair by Hector Foundation II
Institute for Anthropomatics and Robotics (IAR)

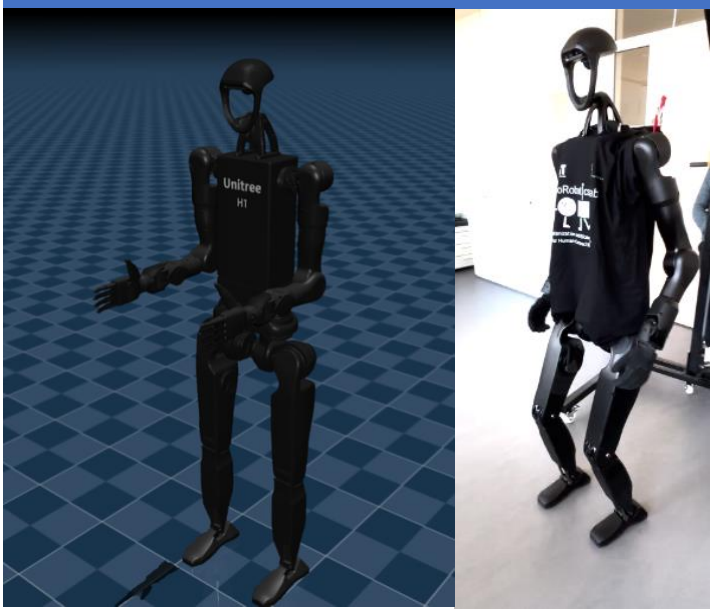
Master's Thesis: Optimization-based Motion Generation and Control for the Humanoid Robot H1

Contact: Prof. Katja Mombaur (katja.mombaur@kit.edu)

Background

The field of whole-body humanoid robots has recently seen an amazing progress with several powerful platforms becoming commercially available. We are getting closer to the vision of humanoids serving humankind by supporting them in monotonous, dirty and dangerous jobs. But teaching new and stable motions to humanoid robots remains a challenge. In addition to reinforcement learning (RL) methods, optimization- or more precisely optimal control-based approaches provide a very interesting and powerful alternative. While the underlying algorithms are different, the two approaches are related as both require precise models of the robot and focus on defining a function (called cost or objective function in the case of optimization and reward function in the case of RL). Optimization provides some advantages over RL in terms of a more flexible formulation of constraints.

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



Scope of the thesis

We offer two different Master's theses topics focusing on optimization-based motion generation and control for the bipedal humanoid robot H1-2 by Unitree, which we recently received in our lab.
The goal is of the first topic to formulate and solve offline optimal control problems to generate motions for the robot and afterwards evaluate these motions on the real humanoid with a precise evaluation of the difference between optimal control solution and real robot's motion (Sim2Real Gap), and the reaction to perturbations. This thesis is based on a detailed model of the robot and should make proposals for improving the model.
The second topic is on real time optimal control / nonlinear model—predictive control of the robot. For this real time task, simplified models of the robot are required. This topic involves model and algorithm development as well as tests on the real robot.

Required knowledge

This thesis requires understanding of mechanical and robotics concepts (Robotics 1 or similar), knowledge on modeling, simulation & optimization (e.g. lecture Simulation & Optimization in Robotics & Biomechanics), and ROS2 and programming knowledge. Experience with humanoid robots from a lecture or previous practical work is a plus.