Optimization, Robotics & Biomechanics (ORB)
Institute of Computer Engineering (ziti)
Heidelberg University

Prof. Dr. Katja Mombaur,
Kevin Stein

Robotics 2 (SS 2019)

Exercise Sheet 8

Presentation during exercises in calendar week 28

Exercise 8.1 – Squatting HeiCub in Muscod

In this sheet we want to revisit the squatting motion from sheet 2 and properly implement it as an optimal control problem. Add the following functions and parameters to the Problem Formulation in icub.cc (Top to bottom):

- Number of Phases, Parameters, Controls and States. We want to exploit the fact, that our model and the squatting motion are symmetric and work with the minimal amount of states and controls. We can use 1 state and 1 control for both knee joints for example. The Squat hight will be a parameter, that we can later optimize.
- Implement the "update_generalized_variables - function". Hip and Ankle joints have opposing frame orientations on the two sides. Therefore you need to add a minus sign when reusing the states. (Similar to Sheet 2).
- Implement a Mayer term for maximizing the squat height.
- Implement a Lagrange function to minimize torques.
- Add a rhs function, update your generalized variables and Compute the Constraint Forward Dynamics.
- Constraint function at the beginning of the squat (6 equality constraints):
- The right foot should not move and be at floor level (the left foot will be symmetric if your model formulation is correct)
- The chest should be 40cm above the ground.
- Constraint function at the during of the squat (1 equality constraint and 3 inequality constraints):
- The chest should be above the feet, to ensure static stability.
- Ensure that the ground reaction force is larger than zero to have a realistic contact.
- The chest height should always be larger than 40cm to ensure an upward motion.
- Constraint function at the end of the squat (1 equality constraint):
- The chest height should be equal to the parameter for the optimization to work.

The DAT file should work out of the box. Compute a squatting motion that maximizes the squat height. How does the motion change if you add a minimum torque objective function?