## Prerequisites
- Robot modeling
- Optimization
- MATLAB and Simulink
- C/C++
- Python
- ROS (Robot Operating System)

## Language
English/German

## Duration
Six months

## Supervisor
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## Description
Inverse dynamics control is very often used in robotics to compute forces and/or torques based on the motion (kinematics) of the robot and its inertial properties. It is well known that relevant system parameters like masses, inertia, the center of gravity vectors, friction parameters, etc. in general are not precisely known, which to some extent, affects the performance of the dynamic inversion based controller. In addition, specific parameters are subject to certain operational fluctuations or cannot a priori be assumed to be constant, such as the load of the end effector, which depends on the robot task. However, mechanical systems have the property that a parameter vector \( p \) can always be found in such a way that it appears linear in the equations of motion, i.e.

\[
M(q)\ddot{q} + C(q, \dot{q})\dot{q} + g(q) = Y(q, \dot{q}, \ddot{q}) p = \tau.
\]

Based on this representation form, adaptive control laws for the Universal Robot UR5 are to be developed and implemented to estimate the parameter vector or parts of it online.

## Goals
- Literature review on existing methods for online robot parameter estimation.
- Analysis and understanding of the derived robot models, and the offline identified system parameters.
- Extend the robot model by the robot end-effector including the load to estimate it online using an adaptive control law.
- Define additional relevant system parameters that are necessary and suitable for online estimation.
- Derive a dynamic inversion based control method with online parameter adaption for the 6DoF robot manipulator UR5.
- Implementation of the developed methods using ROS and execution of different tests with various robot loads.
- Extensive analysis and detailed description of the results compared to the cases with and without parameter identification (on- and offline).