Exercises for Lecture Course on Numerical Optimal Control (NOC)
Albert-Ludwigs-Universität Freiburg – Winter Term 2025 / 26

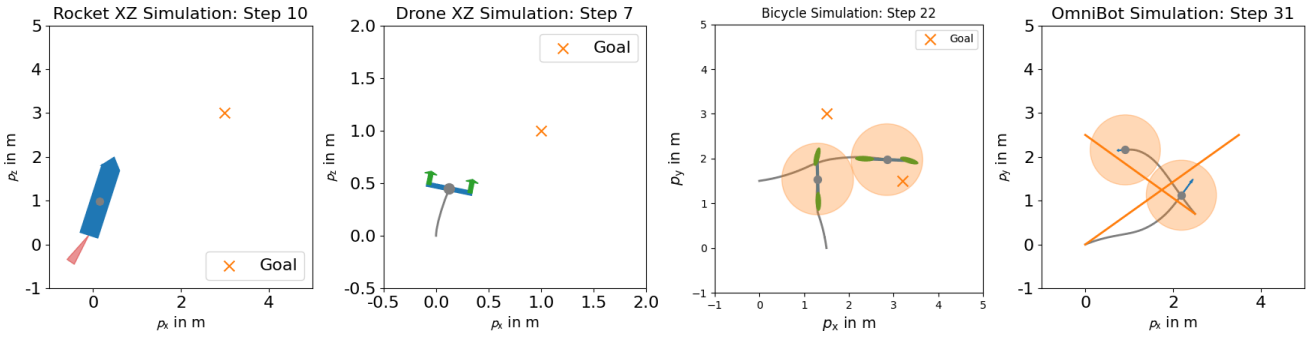
Exercise 8: Modelling of Optimal Control Problems

Florian Messerer, Dr. Armin Nurkanović, Jakob Harzer, Yunfan Gao, Prof. Dr. Moritz Diehl

Obligatory exercise: Show us your results in the session on Dec 9 or 16, 2025.

In this exercise sheet, we learn how to model, formulate, and solve optimal control problems (OCP). As a starting point, we provide several models and OCP formulations as example. These can be found in the the following repository:

`https://github.com/fmesserer/ocp-playground`



1. Familiarize yourself with the repository. Follow the installation instructions, and execute one of the examples in order to make sure everything is set up properly.

2. **Main Task:** Invent your own scenario and formulate and solve as an OCP, using `CasADi` and `IPOPT`. You can use the given models and OCPs as starting points. Do at least one of the following:

   (a) Modify a given OCP by adding more constraints to create more interesting scenarios, for example static or moving obstacles.

   (b) Modify the objective of a given OCP, e.g., let the system track a reference trajectory instead of moving towards a fixed state.

   (c) The bicycle model is kinematic (with positions as states and velocities as controls). Extend it into a dynamic form (with positions and velocities as states, and accelerations or forces as controls).

   (d) Modify a given OCP by adding more agents (you could also mix agents if they move in the same space, e.g., a drone and a rocket).

   (e) (Advanced) Use a given OCP as the basis to implement a model predictive control (MPC) closed-loop scheme.

Passing the exercise: In order to pass the exercise, you need to give a live demonstration of your code in one of the sessions on either Dec 9 or Dec 16. You should be able to (a) explain your code (b) execute your code live (c) do spontaneous modifications based on requests by the teachers. You can use the exercise session on Dec 9 to ask questions, get preliminary feedback, etc.