Exercises for Lecture Course on Numerical Optimal Control (NOC)
Albert-Ludwigs-Universität Freiburg – Summer Term 2019

Exercise 0 – General Information and Environment Setup

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The course's aim is to give an introduction into numerical methods for the solution of optimal control problems in science and engineering. The focus is on both discrete time and continuous time optimal control in continuous state spaces. It is intended for a mixed audience of students from mathematics, physics, engineering and computer science.

1. **Organization of the Course**

   The course relies heavily on self-study based on the lecture videos, course manuscript and exercise sheets. Nonetheless we will meet every Friday, 10:00 to 12:00. Usually every second Friday is dedicated to Q&A regarding the lecture. Normally both professor and teaching assistants will attend the Q&A session. Every other Friday there will be an exercise session with the teaching assistants. You can find a detailed calendar on the course homepage. The course language is English and all communication is made via the course homepage, where you will also find a link to the lecture recordings:

   `www.syscop.de/teaching/ss2019/numerical-optimal-control`.

   In the last third of the semester, some time slots are reserved for project work. The project is optional and worth additional 3 ECTS.

   Exercises: The exercises are mainly computer based. Individual laptops with MATLAB and CasADi installed are required. Please note that the reserved room is *not* a computer pool. The exercises will be distributed beforehand. You can then prepare yourselves for the exercise session, where you can work on the exercises and get help and feedback from the teaching assistants. We may also discuss solutions of previous sheets if there is demand. Solutions to the exercise sheets have to be handed in via e-mail to `messerer@tf.uni-freiburg.de` until the start of the next Q&A session. *Note that because of the biweekly rhythm it will usually be two exercise sheets at the same time.* You will also have to indicate which of the exercises you successfully finished. We will not examine every solution of every student. Note however that we will do extensive random probing. *Indicating a task as solved when this is not true will result in 0 points for the whole sheet.* Also note the guidelines for handing in which you can find below. You will need at least 50% of the total points in order to be eligible for the exam.

   Final Evaluation: The final exam is a written closed book exam. Only pencil, paper, a calculator and four single A4 pages of self-chosen formulas are allowed. For engineering students the final grade of the course (6 ECTS) is based solely on the final exam. Students from the faculty of mathematics need to pass the written exam (ungraded) in order to take a graded oral exam.

   Projects: The optional project (3 ECTS) consists in the formulation and implementation of a self-chosen problem of Numerical Optimal Control, resulting in documented computer code, a project report, and a public presentation. Project work starts in the last third of the semester and participants can work either individually or in groups of two people.

2. **Guidelines for handing in exercises**

For handing in the exercises via e-mail, please adhere to the following guidelines:

- One file which is your main document. It contains your name(s) and a clear indication for every task whether you solved it. A simple format such as .txt suffices. *Claiming tasks as solved when this is not true will result in 0 points for the whole sheet.*
- If there are questions requiring an explicit answer statement (instead of only code) please add them to the main document. Anwers hidden in comments in the middle of the code will be ignored.
- Hand in all of the relevant code files. It should be possible to run them to see all results. It should not be necessary to un(comment) lines for proper functioning. If there are several similar, but conflicting versions (e.g. different constraints), please hand them in as separate files.
- If you received helper functions as part of the exercise, please also hand them in. This makes it easier to run your files since everything is contained in one folder already.
- *Do not copy each other's code. This will result in 0 points for the sheet for all participating parties!*

3. **MATLAB and CasADi Installation**

(a) MATLAB is an environment for numerical computing based on a proprietary language that allows one to easily manipulate matrices and visualize data which will be very helpful in prototyping the algorithms presented during the lectures of this course.

The University of Freiburg offers a free-of-cost license to students and staff which can be obtained following the instructions at the link below:

`www.rz.uni-freiburg.de/services/beschaffung/software/matlab-landeslizenz`

In order to be able to complete the exercises of this course, you will need a working installation of MATLAB. Follow the instructions at the provided link in order to install the software package.

(b) CasADi is a symbolic framework for algorithmic differentiation and numerical optimization. In order to install CasADi, follow the instructions at the link below:

`https://web.casadi.org/get/`.

Download the binaries for your platform and, after having extracted them, add their location to MATLAB's path. To test your installation run the simple example described at the provided link. If successful, save the path by executing the command `savepath`. In this way, the location of the binaries will be known even after restarting MATLAB.