Lecture Course on Numerical Optimal Control
Albert-Ludwigs-Universität Freiburg – Summer Term 2022

Guidelines for the Numerical Optimal Control Project

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As explained at the beginning of the course, you have the possibility of doing a project to get an additional 3 ECTS. The project 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. In the following you will receive some information regarding the scope of the project and our expectations.

If you are interested in doing a project please *let us know via email by the mid-semester deadline announced on the course page*. This is a necessary condition for being allowed to do the project. The email should contain the title of your project, the corresponding authors and a short description of your concept. For application-oriented projects the latter should comprise a description (in words) of your objective, constraints and decision variables. For algorithm-oriented projects the idea of the algorithmic scheme should be briefly discussed. Note that you will not be required to stick to your description, but you should have spend some thoughts on it already. The Q&A session on July 14th is dedicated to the projects. Here, we will help you shape your ideas into feasible projects. Afterwards, you should be committed to a concrete project and start working on it.

1. Make sure that you are properly registered for the project as required by your examination office (registration for the Studien- and/or Prüfungsleistung (SL / PL)).

2. The project can be done in groups of up to three students. If you would like to form a group, but do not have a group mate yet, you can use the forum on Ilias to get in contact with each other.

3. Projects can be either application- or algorithm-oriented. For application-based projects you formulate and solve a self chosen optimal control problem. The focus should be on the mathematical description of your problem (the modeling), its numerical solution and the interpretation of the results. For algorithm-based projects, you choose a scheme for the solution of optimal control problems. The focus is then on the implementation of the scheme and an investigation of its performance, using several test problems / benchmarks. They should illustrate the properties of the algorithm, but need not necessarily have a real-world interpretation.

4. The main result is a written report (approx. 5 pages) submitted as a PDF file. We strongly recommend using LaTeX[1]. You can consider using the official IEEE template for conferences that can be downloaded here:

   `www.ieee.org/conferences_events/conferences/publishing/templates.html`

5. The report must be a new and self-written document and must be solely written by the author(s).

6. The report must include a short, interesting title, the name(s) of the author(s) and an abstract. The content should be clearly structured in sections. It should start with an introduction and conclude with a short summary and critical discussion of the results.

7. The report should contain at least one (selfmade) sketch of the modeled system or implemented algorithm.

8. Figures and tables should have a short caption and be referenced in the text properly, e.g. “the results are shown in Fig. 1”. Use the Latex commands `\caption`, `\label` and `\ref`.

[1] If you have not learned LaTeXyet, see this report as an opportunity. It will certainly pay off for your master’s thesis.

9. Plots must contain physical units and axis descriptions.

10. The report must cite all external sources as references at the end and other people's contributions must be acknowledged. Using other people's ideas and help is allowed, even encouraged. But not citing or acknowledging them properly is fraud.

11. If you use academic open source software to obtain your results, it is also usually a request by the developers that you acknowledge their work by citing the corresponding papers, e.g, "The problem was formulated via the Matlab interface of the symbolic framework CasADi [1] and solved using the interior point method based solver IPOPT [2]."

12. Mathematical or physical variables shall consist of one letter only and be printed in italics. This is automatic in Latex, e.g., a_i as `$a_i$`. Physical units and sub- or superscripts that refer to words are in normal roman letters (use `mathrm` when in Latex mathmode, e.g. x_{initial} as `$x_{\mathrm{initial}}$` or $\frac{\mathrm{kg}}{\mathrm{m}^3}$ as `$\frac{\mathrm{kg}}{\mathrm{m}^3}$`. Write, e.g., $m = 5$ kg (and not $m = 5kg$ or m$= 5$kg).

13. At the end of the semester (see course page), a **short presentation** of approximately 10 minutes[2] will be given by the author(s) to the teacher and the class. The slides can be based on material taken from the report and may contain additional content, e.g. videos, if required.

14. After the presentation you have some time to update your results based on the feedback. The **deadline** for the submission of the **written report and code** is announced on the course page.

15. The **project grade** is based on the form and content of the **report**, the originality and quality of the **results**, and the clarity of the code.

References

[1] J. A. E. Andersson, J. Gillis, G. Horn, J. B. Rawlings, and M. Diehl. CasADi – A software framework for nonlinear optimization and optimal control. *Mathematical Programming Computation*, 11(1):1–36, 2019.

[2] A. Wächter and L. T. Biegler. On the implementation of an interior-point filter line-search algorithm for large-scale nonlinear programming. *Mathematical Programming*, 106(1):25–57, 2006.

[2]The exact time will be announced when the number of projects is known