ME 149: Final Project – [DRAFT]

Optimal Control for Robotics

Assigned: April 3 — Due: April 29 at 11:55pm

Introduction

In the final project for ME 149 you will implement your own trajectory optimization code to solve two or more problems of your choosing. You will start with the basic problem formulations that we have used in the homework and then add a few features to your code to make the project interesting.

Working alone or with a partner

For the final project you may choose to work alone or with a partner. If you choose to work with a partner then you will need to propose a more challenging project (see Advanced Requirements below). How does grading work with a partner? You will submit a single proposal and a single final report, and you will both receive the same grade for the final project.

Basic Requirements

In this project you will implement your own trajectory optimization code. The basic requirements, listed below, must be met by every project submission.

- Implement a direct collocation transcription method
- Solve two different trajectory optimization problems
- Both optimization problems must be solved using the same transcription function — in other words, your transcription should be somewhat general purpose.
- Produce an estimate of the method error that accumulates over each segment of the transcription method.
- The solution of each optimization problem should be clearly conveyed through a set of plots, including initial guess and error estimates.
- Your solution should be in the form of an interpolating spline in addition to the values at the grid points.
- You code should be well written and documented.

Advanced Requirements

In addition to the basic requirements, each project must include some advanced features. I've included a few ideas below, each of which is assigned a difficulty score of one to four points. Your project proposal must have at least three points (for one person) or five points (if working in a pair). You may count the single-point feature multiple times (for example, you would get one point for each additional different optimization problem that you solved). You may suggest additional features in your project proposal if you have ideas that are not listed below.

- Constraints not found in homework problems for this course. [**1 pt**]
- Objective function not found in homework problems for this course. [**1 pt**]
- Use a dynamical system that is not found in the code library for this course. [**1 pt**]
- Implement a forward simulation of your solution using ode45 to compute an additional error estimate, then compare the two estimates. [**1 pt**]
- Solve an additional (different) optimization problem. [**1 pt**]
- Use Hermite–Simpson direct collocation or another medium-order method. [**1 pt**]
- Implement a tracking controller and forward simulation using the solution to one or both of your optimization problems. [**2-3 pt**]
- Solve a multi-phase trajectory optimization problem for one or both systems. [**2-3 pt**]
- Implement analytic gradients in your optimization code and use them for one or both of your systems. Be sure to verify gradients with FMINCON. [**3-4 pt**]
- Implement high-order (orthogonal) direct collocation. Points vary by the generality of your meshing scheme: global collocation / multi-segment, fixed-order / multi-segment, mixed-order. [**2-4 pt**]

Proposal — due April 5

Create a brief proposal (one side of one page) that outlines your plan for the final project. Print out your proposal and bring it to class with you on Thursday April 5. It should include:

- Are you working alone or in a pair? If in a pair, list both partners names.
- Which dynamical system (or systems) are you using?
- Informal description for each optimization problem. Clearly identify the objective and constraint functions.
- Which transcription technique will you be using?
- Which advanced requirements have you selected?

Final Project Submission — due April 29 at 11:55pm

Report and appendix

The primary deliverable for the final project will be a written report, which should be submitted as a pdf document in the style of a conference paper. The report should contain a clear description of the project and the methods that were used. The main body of the report should be not more than four pages with reasonable formatting. The appendix may be as long as you like, although each section in the appendix should be referenced in the main body of the report.

Source Code

The source code for your project should be included as a single compressed archive; do not include it in the pdf appendix. It should be well documented, including a README.md file at the top level that describes what each function does and where the entry point scripts (one for each problem) are. It should also indicate what dependencies your code has.

Media: video [optional]

If your project includes an interesting animation, then you might find it useful to create a video. You can also use the video to explain your methods or other features of the project This can either be included in the upload with your report and source code, or posted to YouTube with a link in your report. Limit the duration of the video to 3 minutes.