ELEC 5660: Introduction to Aerial Robotics
Project 1: Phase 2

Assigned: Feb. 28, 2023 Due: 11:59 PM Mar. 10, 2023

1 Project Work

In phase 1, a controller is implemented and the quadrotor can track a pre-defined trajectory. Phase 2 will focus on a trajectory generator. A carefully designed trajectory generator can enable the quadrotor to operate aggressively and precisely.

1.1 Trajectory Generator

A natural way to command the quadrotor is to set waypoints that it must pass by. What the trajectory generator needs to do is to generate a trajectory that

1. connects all waypoints (including start and goal points).
2. meets smoothness criterion.

1.2 Your Tasks

1. You need to implement a trajectory generator satisfying above two requirements. Three sets of waypoints are provided in **`test_trajectory.m`**. You can choose either 5^{th} order polynomial trajectory or minimum snap trajectory [1]. The later one is our recommendation and will win you bonus points.
2. You need to design two time allocation strategies and analyze the different strategies' impact on the generated trajectories, such as the maximum velocity. Tip: the analysis of both strategies needs to be documented in the report, and only one strategy needs to be included in the code you submit.

1.3 Sample Results

Sample trajectories are shown in Figure. 1.

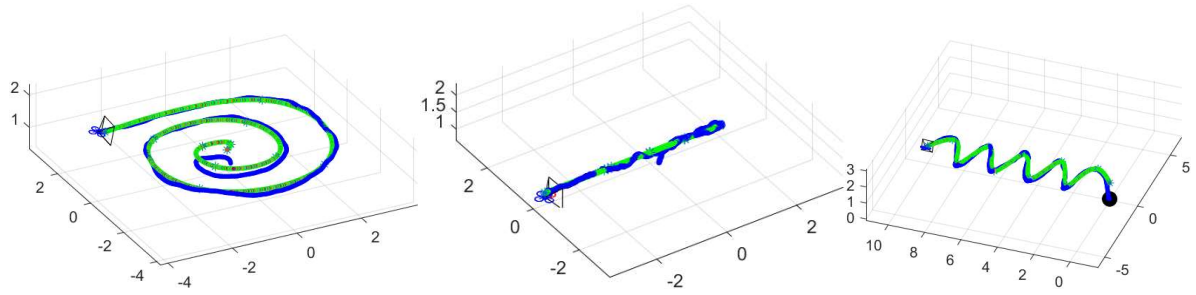

Figure 1: three sample trajectories

2 Structure of Simulator

The simulation code is almost the same but a **`trajectory_generator.m`**. See README.`txt` for details.

3 Tutorial

You can use the naive trajectory generation method in your lecture (only smoothness and connection of waypoints is required), or you can try the optimization-based method (We encourage you generate the trajectory using this method). If you prefer the latter one, you have two ways to implement it.

1. You can use the method in the slides of Lecture 4 or [2] to map the original constrained quadratic program (QP) to an unconstrained QP, and then obtain the closed form solution of the unconstrained QP directly.
2. You can use "quadprog" function in Matlab to solve the constrained QP. This function is originated in Matlab, and you can type in "help quadprog" in the command window for more detail.

4 Submission

When you finish the assignment, you may submit your code and documents on **canvas** before **Mar. 10, 2023 23:59:00**. The project name for this assignment is titled "`proj1phase2`".

Your submission should contain:

1. A **maximum 2-page** document including:
   (a) A brief introduction of the trajectory generation method you used.
   (b) Figures plotted by simulator.
   (c) Statistics about your controller. (For example, RMS error between current state and desired state for position, velocity).
   (d) Analysis of your time allocation strategies. (For example, the maximum velocity).
   (e) Analysis of your result. (For example, parameter studies).
   (f) Any other things we should be aware of.
2. Folder `code` containing files **`controller.m`**, **`trajectory_generator.m`**, as well as any other Matlab files you need to run your code.

You will be graded on the successful completion of the code and how quickly and accurately your quadrotor follows the generated trajectory. This time we will also test one other set of waypoints which will not be released.

References

[1] D. Mellinger and V. Kumar, "Minimum snap trajectory generation and control for quadrotors," in *Proc. of the IEEE Int. Conf. on Robotics and Automation*, Shanghai, China, May 2011.

[2] A. Bry, C. Richter, A. Bachrach, and N. Roy, "Aggressive flight of fixed-wing and quadrotor aircraft in dense indoor environments," *The International Journal of Robotics Research*, vol. 34, no. 7, pp. 969–1002, 2015.