Assignment 7: Differential Flatness Quad-rotor control Using LQR

Due

10/24/2014

This homework is based on the differential flatness paper [**?**] discussed in the class. You can also download "Differential Flatness-based Quadrotor Control2.pdf" from canvas for detailed implementation. You will also need to download "Diff Flat Quad Control Dummy.zip". Here are some instructions for the assignment.

- Do not discuss or share your code and Q and R matrices with fellow students.
- Matlab can be used all the time.
- The grading is relative, the student with minimum tracking error will receive 100% points.

1. Design a LQR controller for a quadrotor to track y_{traj}. The objective is minimize the tracking error $x - x^r$ meaning find the best Q and R weighting matrices and then showing that the gain matrix K computed based on Q and R matrices gives you the minimum tracking error.

$$y_{traj}(t) = \begin{bmatrix} p_n^r(t) \\ p_e^r(t) \\ p_d^r(t) \\ \psi^r(t) \end{bmatrix} = \begin{bmatrix} a\cos(\omega_2 t) \\ b\sin(\omega_1 t) \\ n + c\sin(\omega_3 t) \\ \psi^r(t) \end{bmatrix}$$

   where $\omega_1 = \frac{2\pi}{T}$ for the following four scenarios

   (a) $a = 1.5$, $b = 0.75$, $c = 0$, $n = -0.75$, $\omega_2 = \frac{\omega_1}{2}$, $\omega_3 = \omega_1$ and $T = 5s$.

(b) $a = 1.5$, $b = 0.75$, $c = 0.5$, $n = -0.75$, $\omega_2 = \frac{\omega_1}{2}$, $\omega_3 = \omega_1$ and $T = 10s$.

(c) $a = 0.75$, $b = 0.75$, $c = 0$, $n = -0.75$, $\omega_2 = \omega_1$, $\omega_3 = \omega_1$ and $T = 10s$.

(d) Generate an unique trajectory (what ever you can cook up) and track it using the LQR controller.

Instructions for using "Diff Flat Quad Control Dummy.zip". You will be using the following 5 files to complete this assignment.

1. "param.m" : In this file you will

   (a) change the trajectory parameters for different trajectories.

   (b) set up A, B, b, based on the state-space equations derived in the paper and the class.

   (c) select Q and R and compute optimal gain matrix K using LQR command in the MATLAB.

   (d) run "param.m" before running "QuadControl_TrajectoryControl_I.slx".

2. "trajectory.m": For first three parts you do not have to change any thing in this file. But you may want to change this for part 4, your unique trajectory, you can change it.

3. "TrajControlI_diffFlatness.m": In this file you find control u and then use inverse mapping to find ν (control input for quadrotor) as described in the paper.

4. "QuadControl_TrajectoryControl_I.slx": This is the main Simulink File. You have to run "param.m" before runing this file.

5. "plotStates.m": After you run the "QuadControl_TrajectoryControl_I.slx" run this file to generate all the plots. This file will give you two types of error maximum position error and root mean square error. These errors will be used to judge the quality of your controller. Include these plots and the maximum position error in your submission.

References