ESC794: Selected Topics in Engineering Science
Model Predictive Control

Homework 5. Due: 11/15/18. Matlab code and report as a pdf must be received by email by 5 PM.

1 Work out every step of the proof of Lemmas 5.2 and 5.4 in the textbook by Grüne and Pannek, finding a justification for each step taken. Be prepared to discuss your reasoning during class on 11/20.

2
Make a small modification to the discrete-time MPC code provided by the instructor (`MPCdlqrNoTerminal.m`) to include a terminal equilibrium constraint. Simulate the constraint-free and the equilibrium terminal constraint cases under the same cost function, horizon and initial conditions. In each case, show time plots of the predicted trajectories and the closed-loop trajectories. Comment on the results.

3
Make a small modification to the continuous-time MPC code provided by the instructor (`CTdoubleIntMPCNoTerm.m`) to include a terminal equilibrium constraint. Simulate the constraint-free case with $T = 0.5$ and $\delta = 0.05$ ($N = 10$), with $Q = I$ and $R = 1$, using the provided initial condition. Then simulate the terminal equilibrium case under the same conditions. Comment on the results.

4
For the continuous-time double-integrator plant with input constraints $\mathbb{U} = [-1\ 1]$, use the linear method described in class to find an ellipsoidal terminal region and a terminal cost. Use $Q = I$ and $R = 1$ and $\delta = 0.1$. Then implement MPC with terminal set constraints and terminal cost. Tune the horizon for a compromise between initial feasibility and optimization speed (i.e., you may allow some infeasibility for the first few OPC runs, using `fmincon`'s maximum iteration limit to keep going). Use $T = 1.5$ initially.
It is recommended to use an initial guess based on a simulation of the plant with some arbitrary control input (such as a constant). Provide a phase plot of the predicted and actual closed-loop trajectories and show the terminal set. Experiment with α smaller than the maximum allowed for U_{max}.

5
Use ACADO to simulate an MPC controller according to Problem 5.8 in Grüne and Pannek ($N = 2$). Use the supplied discrete-time example and make small modifications. Verify that the closed-loop system is asymptotically stable.

6 (Extra credit, due with the final project)
Investigate a way to use a terminal cost and a terminal set constraint for an OPC solved with ACADO. Then simulate Problem 4 above using this package. Comment on any computational speed advantages.