CLEMSON
AUTOMOTIVE ENGINEERING

AuE 8930- Robust Predictive Control **Fall 2020**

Homework 2 –Steady State Target and Constrained Linear MPC

Assigned: 09-10-2020 **Due: 09-25-2020** **5:00PM** **Submit PDF on CANVAS**

Instructions:

A) Please submit your work as a well-organized report showing work steps with results and discussions as a single PDF (file name: YOUR LASTNAME_HWK1). You may either type or scan-in any handwritten items but merge and label those at the correct locations in your document. Include plot outputs within the same document at the corresponding locations; MATLAB codes may be included as Appendix, if relevant. Please annotate figures/plots clearly with legible font sizes and legends as necessary.

B) Explain your steps and results. Work submitted without any effort to explain your steps and results will be graded poorly (up to 50% for the score assigned for that part).

Problem Set Complete the following exercises in the text by Rawlings et al, 2nd edition

1. **Exercise 1.54.** Where is the steady state? Apply the following hints to the problem statement given in each of the parts a), b) and c). You may or may not need (static) optimization to solve the individual parts. Use quadratic objective functions when you need to.
   - First solve for the target triple (x_s, u_s, y_s) disregarding the given input set point u_{sp} and decide if the output set point is feasible or not. Note: $y_s = Cx_s$ can be computed from x_s.
   - Solve for the same target triple as in part a (disregarding the u_{sp}) for the input configuration and weight stated there and decide whether or not the output set point is feasible. If not, remove the output set point equality constraint $y_s = y_{sp}$ and re-solve for the target triple considering only tracking of the output set point in your objective function.
   - Solve for the same target triple as in part a for the input and output configuration and weight given there and decide on the feasibility of the output setpoint given. If the output set point is feasible, you only need to consider tracking of the input set point in this part.

2. **Exercise 2.18**. Design MPC for Multi-variable constrained plant. Notes:
   - S is the penalty/weight on the input rate of change.
   - Set $Q = C'C$, and use N=40, R=I and S=I
   - In each part b,c,d, you are to 're-design' the MPC for the specified constraints and simulate it.
   - For part d, design a Kalman filter with the process and measurement noise covariances as follows to achieve the output variance stated in the problem.
     $Q_\omega = diag\left(O_3, O_2, 10^{-4}eye(2)\right)\ and\ \ R_v = 0.01eye(2)$
     The process noise covariance matrix Q_ω models zero noise in the state $\boldsymbol{x}$, and the past inputs for the rate of change penalty, and small covariance on the two-dimensional disturbance outputs. R_v is the measurement noise covariance.

     Note, if you choose not to include integrating disturbances (no good reason you shouldn't as there is minimal added complexity), Q_ω needs to be modified. Don't make it 0.