SSY281 Model Predictive Control

Assignment 7

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March 11, 2020

Question 1

To guarantee asymptotic stability for all $x0 \in \mathbf{X_0}$ we choose the terminal state weight (terminal penalty) to the unconstrained LQ problem, which is the solution to the algebraic riccati equation. This was found using the developed method in assignment 5 (Pf_14.m) which uses the *Matlab* function **idare()** internally. The set $\mathbf{X_0}$ can be seen in figure 1.

$$P_f = \begin{bmatrix} 16.0929 & 32.9899 \\ 32.9899 & 93.9396 \end{bmatrix} \tag{1}$$

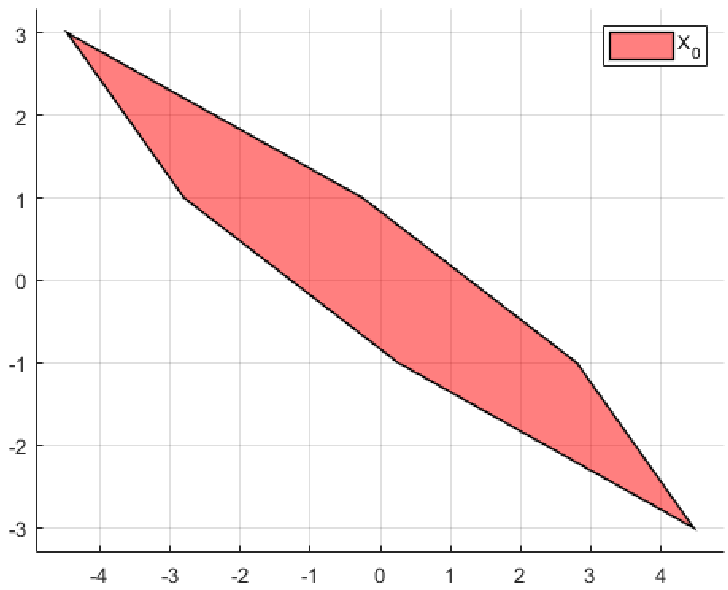
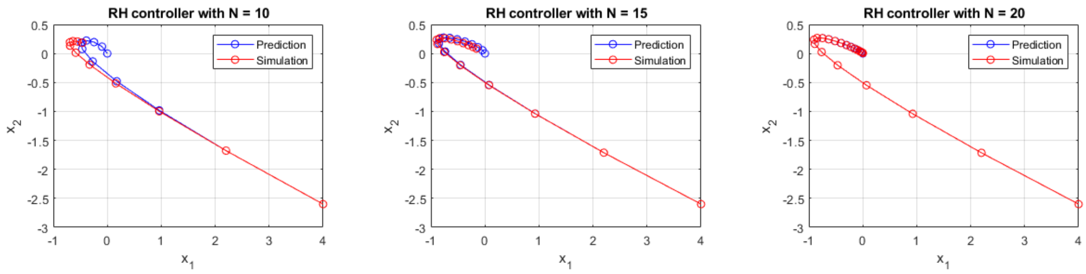


Figure 1: All $x_0 \in \mathbf{X_0}$ guaranteeing asymptotic stability

Question 2

The open loop predictions and closed loop simulations for the different prediction horizons can be seen in figure 2 where the longer prediction horizon creates more similar results. The reason for the predictions and simulations differing is that the



N = 10 *N = 15* *N = 20*

Figure 2: Prediction and simulation of the RH controller

prediction only calculates N steps ahead from the initial point and that's it while the simulation calculates N steps forward from it's current point. This means that at e.g the third step into the simulation it will calculate the optimal sequence for 10 steps forward from the current point and not the initial point, which is 13 steps from the initial point. Hence the closed loop simulation acts as how we think about the **receding horizon** controller, it moves along. In the figures we see that for small N they differ a lot and the simulation does not get close to the origin. This feels like it's breaking the constraint of $X_f = \mathbf{0}$ but it doesn't since in it's prediction it will be at the origin in 10 steps and hence not violating the terminal state constraint! The simulation has found a more optimal way in terms of the given control and state weights (Q and R) when it can reiterate at each point. When N is increased the prediction and simulation will move closer since they will both approach the more optimal solution.

Question 3

Persistent feasibility can be guaranteed if X_f is control invariant as stated in Theorem 9.4 in the book and hence a subset of C_∞. Since we are given that x_0 belonging to C_∞ ($X_N \in C_\infty$) and we should reach X_f in one step we could calculate the terminal state set as:

$$X_f = \mathrm{Reach}(X_N) \cup C_\infty \tag{2}$$

Question 4

Did not make.