SSY281 - Model Predictive Control
Micro-Assignment MA07 - MPC practice

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Question 1 *Consider the RH controller in slide 46. If the initial state of the plant x0 is admissible, will the RH controller be feasible at all time?*

Unfortunately, even if the initial state is feasible, there is no guarantees that the successor state will also belong to the feasible set.

Question 2 *How can we guarantee that the state of a dynamical system, in closed-loop with a MPC controller, evolves along trajectories such that the optimization problem will remain feasible at all times?*

In theory, we need the feasible set $\mathcal{X}_N$ to be positively invariant for the close loop system:

$$x(0) \in \mathcal{X}_N \quad \Rightarrow \quad x(k+1) = f(x(k), \kappa_N(x(k))) \in \mathcal{X}_N \tag{1}$$

then it is guaranteed that the optimization problem to be solved at every time instant is feasible, provided the initial state is feasible.

In addition, a sufficient condition for recursively stability is satisfied if the terminal constraint set $\mathbb{X}_f$ is control invariant:

$$x \in \mathbb{X}_f \quad \Rightarrow \quad \exists u \in \mathcal{U} \text{ such that } x^+ = f(x, u) \in \mathcal{X}_f \tag{2}$$

where $\mathcal{X}_N$ might be defined as $\mathcal{X}_N = K_N(\mathbb{X}_f)$

Question 3 *What are the pros and cons of having a really small terminal set, like Xf = 0, versus a large terminal set, like Xf = Rn.*

The main advantage of using a large terminal constraint $\mathbb{X}_f$ and a large prediction horizon N is that this results in a larger feasible set $\mathcal{X}_N$. On the other hand, the smaller $\mathbb{X}_f$, the better the controller performance.

Question 4 *Consider a RH controller, with a terminal set constraint $\mathbb{X}_f$. How can you prevent infeasibility other than with the method you proposed in Question 2? Explain pros and cons of your solution.*

Another option is to make use of constraint management, such that the constraints are softened. In this way, there will be always a feasible solution, however the constraints might be slightly violated.