SSY281 - Multi Predictive Control

MPC practice - Implementation and Tuning

Micro Assignment - 10

ID-Number 43

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1 Answers

1.1 Question 1: Practical consequence of infeasible RHC

The practical consequence of the possibility that the RHC becomes infeasible is that it is become a required thing for all practical RHC implementations to have a mechanism to recover from infeasibility. Algorithm should become a means to recover from infeasibility. Moreover, the capability of the algorithm used to deliver the control action according to specification is also becoming integral.

1.2 Question 2: How to avoid risk of infeasibility

Here we will present several practical method to avoid risk of infeasibility.[2]

1. **Process Dependent Constraint Softening**
   This could be done by the following steps :
   1. Relax or remove least important soft constraints and test for feasiblity
   2. Relax or remove next most important constraints and test for feasiblity
   3. Etc.

   The decision making for the process above is taken by a supervisory controller before constraints are downloaded to the MPC algorithms.

2. **Infinity norm Constraint Softening**
   First, we define a variable $\mathbf{s} \geq 0$ and replace the soft constraints with

   $$C_s u + H_s x - d_s \leq s \tag{1}$$

   The positive value vector **s** defines the constraint violations. The method could then be implemented by minimizing maximum weighted value of **s** such that hard constraints and terminal constraints are satisfied. The drawback is that this method does not take into account the performance of the RHC.

3. **Back off and Borders Method**
   This method is based on the presumption of not to drive the system to the input limits, but to leave some extra freedom for emergencies. Let the actual input limits be

   $$u_{k+1} \leq \bar{u}, \forall i \tag{2}$$

   The *back off* is then added to the constraint expressed in terms of a time dependent value b_i such that

   $$u_{k+1} \leq \bar{u} - b_i, \forall i \tag{3}$$

   where $b_i \geq b_{i-1}$. By using the constraint above on the prediction, it will improve control capacity at each sample against various uncertainties.

1.3 Question 3: Banded Matrices Significance

The significance of banded matrices usage on QP problems could be summarized as below[3]:

1. It will improve the computational efficiency of the algorithm by reducing the order of the operations significantly.

2. Since the coefficient matrix in the QP minimization problem becomes a narrow-banded matrix, it will make it relatively more easily to factor using available software.

1.4 Question 4: How to reduce control signal value in RHC

It could be done by using *blocking method* by keeping the control signal constant over several sampling variables. This method requires a piecewise constant u ($\Delta u = 0$) for several blocks of sampling instant. Consequently, this will gives fewer decision variables which in turn improve computational efficiency of RHC system. Input blocking is illustrated in Figure 1 where a single input is changed at each sampling instant for the first four sampling instants (k through $k+3$). Starting at $k = 4$, u is blocked so that it changes every three sampling instants until the steady-state value is reached at $k = 13$. To implement this method successfully, we need to set the **time to start the blocking** as well as **the duration of the blocking**.

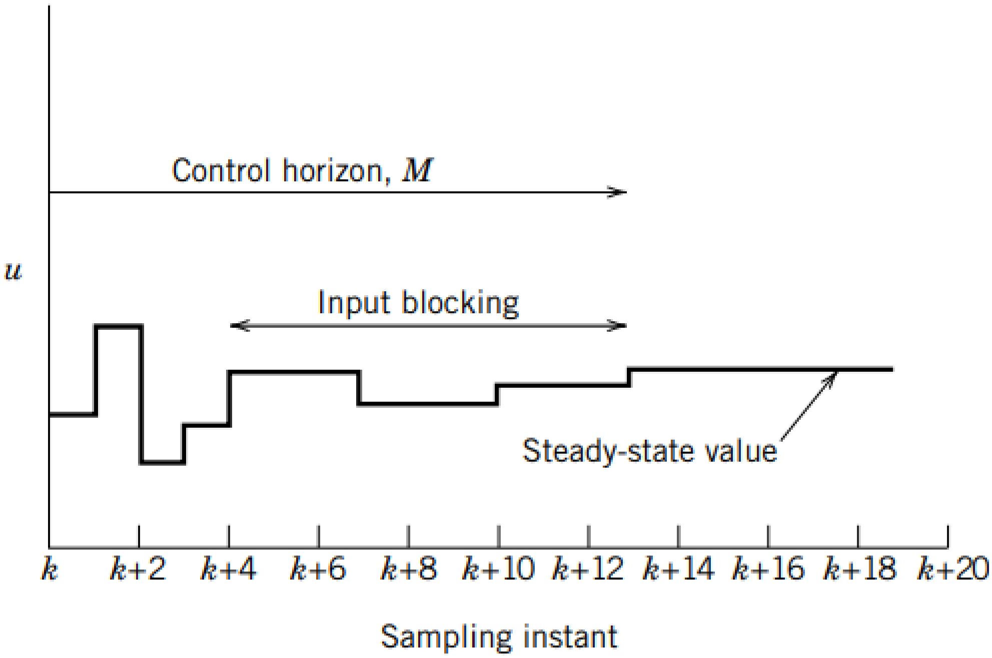

Figure 1: Input blocking method Illustration [1]

2 REFERENCES

[1] Seborg et al. Process Dynamics and Control.Wiley; 3rd edition, 2010, Chapter 20.
[2] Rossiter, J.A.. Model Predictive Control - A Practical Approach. CRC Press LLC. 2004, Chapter 8.
[3] Wright, S.J. APPLYING NEW OPTIMIZATION ALGORITHMS TO MODEL PREDICTIVE CONTROL. Accessed from : **www.citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.379.4621rep=rep1type=pdf**