Model Predictive Control using MATLAB
10: Further topics

by
Midhun T. Augustine

Overview

Advanced topics in MPC

Advanced topics in MPC

1. **Adaptive MPC**: in which the model parameters are estimated online and the MPC is designed for the estimated model.
2. **Robust MPC**: considers MPC of uncertain systems with bounded uncertainties:

$$\mathbf{x}_{k+1} = \mathbf{f}(\mathbf{x}_k, \mathbf{u}_k, \mathbf{w}_k) \tag{1}$$

   where $\mathbf{w}_k \in \mathbb{W}$. $\mathbb{W}$ is a bounded set (usually polytope).

3. **Stochastic MPC**: considers MPC of uncertain systems with stochastic uncertainties:

$$\bar{\mathbf{x}}_{k+1} = \mathbf{f}(\bar{\mathbf{x}}_k, \mathbf{u}_k, \bar{\mathbf{w}}_k) \tag{2}$$

   in which $\mathbf{w}_k, \mathbf{x}_0$ are random vectors.

Advanced topics in MPC

1. **Hybrid MPC**: deals with MPC of hybrid systems which are dynamical systems that has both continuous dynamics and discrete dynamics.
   Eg. Switched systems: which consists of a number of subsystems and a switching rule ($i = \sigma(k)$) that governs switching among the subsystems.

$$\mathbf{x}_{k+1} = \mathbf{f}_i(\mathbf{x}_k, \mathbf{u}_k) \tag{3}$$

   where $i \in \mathbb{M} = \{1, 2, ..., M\}$ and $\mathbb{M}$ is the set of subsystems.

2. **Distributed MPC**: considers MPC of distributed systems which consists of a number of local subsystems and a network over which the local systems communicate.

$$\mathbf{x}_{i_{k+1}} = \mathbf{f}(\mathbf{x}_{i_k}, \mathbf{u}_{i_k}) \tag{4}$$

   where $i \in \mathbb{M} = \{1, 2, ..., M\}$ and $\mathbb{M}$ is the set of subsystems

Applications of MPC

Applications of MPC

1. **Process industries**: initial applications of MPC mainly consists of the chemical and process industries. Initial versions of MPC: Generalized predictive control (GPC) and dynamic matrix control (DMC).
2. **Mechanical systems**: ability to handle constraints makes MPC suitable for controlling robots, automobiles and aerospace vehicles.
3. **Power converters**: recently MPC is extensively used in controlling power converters.
4. **Network systems**: one of the major future applications of MPC.

References

References

- F. Borrelli, A. Bemporad and M. Morari *"Predictive Control for Linear and Hybrid Systems"*, Cambridge University Press, 2017.
- L. Grune and J. Pannek *"Nonlinear Model Predictive Control: Theory and Algorithms"*, Springer, 2011.
- D. Luenberger and Y. Ye *"Linear and Nonlinear Programming: Fourth edition "*, Springer, 2008.
- D. Mayne, *"Model Predictive Control: Recent Developments and Future promise"*, Automatica, Issue 50, pp. 2967-2986, 2014.
- M. Guay, V. Adetola and D. Dehaan, *"Robust and Adaptive Model Predictive Control of Nonlinear Systems "*, The Institution of Engineering and Technology, 2015.
- B. Kouvaritakis and M. Cannon, *"Model Predictive Control: Classical, Robust and Stochastic"*, Springer, 2016.
- S. Rakovic and W. Levine, *"Handbook of Model Predictive Control"*, Springer, 2019.

Thank you

Contact: midhunta30@gmail.com