Robustified Nonlinear Model Predictive Control via a Min-Max Formulation

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Abstract: Nonlinear model predictive control (NMPC) is an appealing control method as it allows to control multi-input multi-output processes while taking constraints into account. It is based on successively solving open-loop optimal control problems. Although NMPC schemes may naturally exhibit a certain degree of inherent robustness, an explicit consideration of process uncertainties is preferable, particularly for processes with increased demands on safety.

This is achieved by treating the optimization involved with NMPC as a min-max formulation that considers the worst-case combination of unknown process parameters such as reaction rates in chemical processes [1]. The resulting semi-infinite programming problem is solved approximately by a first-order expansion of the inner maximization problem as recently proposed in [2].

It is demonstrated how this method offers a systematic way to design safety margins for the controller. Furthermore, information about the stochastic nature of the uncertain parameters, coming, e.g., from state and parameter estimation, can be incorporated on-line. The proposed robustified NMPC scheme is then applied to the model of an exothermic batch reactor to avoid thermal runaways. These can lead to severe accidents and damages to the equipment and are very sensitive towards uncertain parameters. The example shows the benefit of a robustified NMPC scheme and underlines the general advantages of model-based control, where the desired control task can conveniently be formulated by appropriate path constraints and cost functions.

References:

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