A Model Reduction Technique for linear Model Predictive Control of Non-linear Large Scale Distributed Systems

Weiguo Xie and Constantinos Theodoropoulos*

School of Chemical Engineering and Analytical Science, University of Manchester, Manchester, M60 1QD, United Kingdom

ABSTRACT:

MPC (Model Predictive Control) is widely used in the process industries. Over the last two decades, linear MPC has become a popular and effective advanced control strategy. However, linear models often do not adequately describe the dynamics of the (complex) process to be controlled except near the point at which the model was identified [1]. In general, nonlinear large-scale distributed system models lead to expensive computations, which also restrict the application of MPC in this area. Therefore, nonlinear MPC is mostly used in batch operations, while linear MPC is more often used in continuous operations [2].

Model reduction techniques have been used in conjunction with nonlinear MPC for the distributed systems (e.g. [3]). The main purpose of this is to develop a model reduction-based methodology to efficiently apply linear MPC techniques for non-linear distributed-parameter systems. A technique combining the POD (proper orthogonal decomposition) method the finite element method and TPWL (Trajectory piecewise-linear) approximations has been developed. The linearisation of even very high-dimensional systems is effectively reduced to a set of 1-dimensional linearisations with respect to time. This technique can have significant impact in the applicability of mutli-parametric MPC to large-scale systems.

The primary tool for solving the nonlinear MPC is SQP (successive quadratic programming). Normally, in order to perform effective control, on-line computational cost has been traded with on-line storage requirements. Furthermore, SQP often leads to undesired local minima. Therefore, a way is necessary to automatically select the number and location of linearization points so as to give the best TPWL approximation to the nonlinear model up to a given tolerance. By then, QP (quadratic programming) without iterations can be applied for TPWL approximation instead of SQP. The methodology is discussed with the aid of illustrative continuous and discrete benchmarking examples.

References:

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* Corresponding author: k.theodoropoulos@manchester.ac.uk

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