A quasi-Model Predictive Control and its application to a grinding circuit

Zakharov A., Jämsä-Jounela S.-L.

Aalto University, School of Chemical Technology, Research group on Process Control and Automation, P.O.Box 16100, FI-00076, Aalto, Finland (e-mail alexey.zakharov@alto.fi)

Extended abstract

Model predictive control (MPC) is nowadays one of the leading multivariate control techniques used in industry. The computation requirements of MPCs are constantly growing due to both the increased complexity of control systems involving more variables and the increasing use of nonlinear models. That is why many researchers have concentrated their efforts on reducing on-line computations of MPC. In particular, the explicit MPC precomputes the piecewise linear control law. However, because of the exponential explosion of the number of pieces as a function of the number of problem inputs, outputs and constraints, this approach is only suitable for small-scale problems. Partial enumeration approach precomputes the optimal solutions for the most frequently occurring sets of active constraints. This approach combines the table storage method and the on-line optimization, which makes it suitable for large control problems. On the other hand, several modifications of the optimization algorithms were proposed exploring the structure of the QP tasks related to the MPC objective optimization.

This paper proposes a quasi-Model Predictive Control (qMPC), which is a constrained controller aiming to completely avoid MPC optimization and achieve control performance similar to the one of the common QP-MPC. In more details, the objective of the MPC optimization is usually written as follows:

$$J(x_0) = \min_u \sum_k L^x(x_k) + L^u(\Delta u_k),$$

where x_k is the state of the process at time instant k, u_k is the input value at time k, and L^x and L^u are some non-negatively definite quadratic forms. The common QP-MPC approach is to define L^x and L^u and to carry out QP optimization to obtain the optimal value of the objective $J(x_0)$ and the optimal sequence of control actions. In contrast, the qMPC approach, devised in this paper, defines the $J(x_0)$ and L^u terms, and then directly computes the current control action u_0 without knowing the L^x term. Next, the optimization objective $J(x_0)$ is designed to take into account the process constraints.

Simulation study has been conducted to compare the performance of the qMPC and the common QP-MPC methods on a grinding circuit model, having two inputs and four constrained outputs. The simulation results confirmed similar performance of both methods and also the ability of qMPC to avoid constraints violation. On the other hand, as the qMPC does not require any optimization, its computational load is very low.