Feedback Control for Optimal Process Operation Revisited: Models, Data, and Robustness

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In my ADCHEM 2006 Plenary Talk, I advertised to consider feedback control as a means to achieve optimal process operation, beyond regulating key variables of a process to the desired setpoints. Specifically, I pointed out that model predictive control with rigorous models has the potential to achieve economically optimal dynamic operation and that it is computationally feasible (Engell, 2007). This idea has since been pursued in many works, under different names, e.g. eNMPC, DRTO. Tailored solutions based on this principle are applied industrially, e.g. in the minimization of the batch time of polymerizations. Other proposals aim at establishing optimality without employing models explicitly as e.g. "self-optimizing control" and "extremum-seeking control." Still, in the design of such schemes, models are also used.

To build good models of complex processes is a demanding task. Even if large efforts have been invested into modelling, the behavior of a real process will always deviate from the model predictions. The use of measured data can compensate these deficiencies, that is why feedback is employed, but controllers can also fail due to model errors. There is a broad spectrum of possible combinations of using models and data, from using models only in the design of control algorithms to relying on model predictions and using only simple correction schemes, or adapting models online.

Generally, one is interested in techniques that provide good performance without requiring huge modelling efforts. In the talk, we discuss two approaches to reducing the negative effects of model errors in optimization and control that represent different generic concepts. For real-time optimization, we outline the so-called modifier adaptation approach, which adds a data-based local model to a global nonlinear model and updates it iteratively to ensure convergence to the true optimum of the real plant. As an example of robust control, the multi-stage MPC approach is presented in which the presence of future information on the realization of the model uncertainty is included in the optimization to reduce conservatism.

Finally, the idea of replacing rigorous models by "machine learning", possible pitfalls and strategies to handle model deficiencies in this context will be discussed.

Keywords: Process control; Process optimization; Modeling and identification

REFERENCES

Engell, S. (2007): Feedback control for optimal process operation. Journal of Process Control 17, 203-219.