Overview of online process optimization approaches

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Abstract. This tutorial workshop discusses various approaches to online process optimization, where the objective is usually to minimize an economic cost. Steady-state real-time optimization (RTO) has been around for more than 25 years, but still it is not used much in practice. One reason is the steady-state wait time, because one has to wait for a new steady state before the process is re-optimized. This tutorial workshop aims to provide an overview of the different RTO approaches:

1. Traditional steady-state RTO
2. Dynamic real-time optimization (DRTO) / Economic model predictive control (EMPC)
3. Hybrid RTO - Steady-state RTO with dynamic model update (new method)
4. Feedback-based Hybrid RTO (new method)
5. Extremum seeking control ("Data-driven" optimization)
6. Optimal operation using classical advanced control

In the conventional steady state RTO, one must wait for the process to reach steady state before updating the model using "data reconciliation". As a result of the steady-state wait time, large chunks of transient data are often discarded. An obvious solution to this issue is to use dynamic RTO or economic NMPC. However, these methods can be computationally expensive.

In order to address this issue, in the hybrid RTO approach, we solve the same steady-state optimization problem as in traditional steady state RTO, but instead of a steady-state model update, we use dynamic model adaptation with use of transient measurements, for example, using an extended Kalman Filter. This avoids the steady-state wait time. In the feedback-based hybrid RTO approach, we do not solve the steady-state optimization problem numerically as in conventional RTO, but instead the steady-state gradient is estimated by linearizing the nonlinear dynamic model around the current operating point. The gradient is controlled to zero using standard feedback controllers, for example, a PI-controller.

Unlike model-based methods, data driven methods such as extremum seeking control that rely on estimating the plant-gradients directly from the measurements, can effectively handle structural mismatch. However, this requires the assumption that the plant cost can be measured and in addition, the convergence of such methods are generally very slow, due to the steady-state wait time. We show how transient measurements can be used along with such methods.

We also present solutions using classical advanced control, where optimal operation can be achieved using PID controllers with simple logics such as split range control, selectors etc.

With the recent developments of various approaches to online process optimization with varying degrees of complexity and flexibility, different methods work in different timescales and can handle different kinds of uncertainty. This workshop will give an overview and classification of the different approaches available in the RTO "toolbox" and discusses the advantages and disadvantages of the different methods.