technische universität dortmund

Fakultät Bio- und Chemieingenieurwesen
LS für Systemdynamik und Prozessführung

Diplomarbeit / Masterarbeit

Price-based Optimizing Control of Distributed Processing Systems

Background

Optimizing control methods such as *(economic) model-predictive control* (MPC) and *real-time optimization* (RTO) are increasingly employed in the processing industries as they enable a more productive operation without the need for equipment or process changes, leading to a significantly higher process utilization and revenue for chemical companies. Most optimizing controllers today consider only small process units in a centralized fashion, although an increasing world-wide competition among chemical providers requires the development of more encompassing *plant-wide optimization approaches* for the computation of optimal operation strategies not only for units, but for complete plants or even processing sites. As the size and complexity of modern processing systems goes beyond the capabilities of centralized optimization approaches, recently distributed optimization and control techniques have emerged. In these, a central arbiter coordinates between several smaller optimizers for local problems and tries to drive the overall solution to the global optimum. A promising approach to distributed optimization and control is the use of price-based coordination mechanisms. Such mechanisms have also been proposed and successfully tested in large discrete resource allocation problems and often are labeled as agent- (or auction)-based systems. The underlying idea is to coordinate the use of scarce resources by a bidding procedure where the "agents" offer and buy resources at certain prices that then enter into the local cost functions [1,2].

Objectives

The objective of this thesis is to develop an *price-based distributed optimization algorithm* that, using local optimizations, determines a globally (sub-)optimal solution to the overall optimizing control problem on a *moving horizon*. The local optimization problems must be solved using a nonlinear model-predictive control (NMPC) scheme that was developed at the DYN group [3]. The distributed optimization algorithm must be demonstrated and evaluated on a networked system of Chylla-Haase semi-batch reactors (see [3]), where the student is free to create a suitable, challenging networking structure for the reactors.

Steps

a) Familiarization with decomposition methods and distributed optimization algorithms (e.g. Lagrangean relaxation techniques, Dantzig-Wolfe decomposition, price-based algorithms), with the NMPC scheme described in [3], and with the Chylla-Haase reactor model (which is already available).

b) Definition and implementation of a suitable, challenging case study for distributed optimization based on Chylla-Haase reactors, including global and local cost functions.

c) Implementation of a software architecture that enables the use the NMPC algorithm as a local optimizer, coordinated by a centralized auctioneering algorithm.

d) Development and implementation of a suitable price-based coordination mechanism that should be generic to be applicable to general distributed systems (the development itself should be guided by the case study).

e) Integration of the distributed optimization algorithm into a moving-horizon scheme.

f) Application and evaluation of the moving-horizon distributed optimizer on the case study.

g) Preparation of a thesis report that contains all results of the project, including a survey of distributed optimization and its potential in the processing industries, a comprehensive and concise case study description, a description of the moving-horizon distributed optimization algorithm, and all results of the application and evaluation of the distributed optimization to the case study.

Duration

6 months, fulltime

Supervisors

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Literature

[1] E. Kutanoglu, S. D. Wu: On Combinatorial Auction and Lagrangean Relaxation for Distributed Resource Scheduling. In *IIE Transactions 31*, 1999, pp. 813-826.

[2] M.P. Wellman, W.E. Walsh: Auction Protocols for Decentralized Scheduling. In *Games and Economic Behavior 35*, 2001, pp. 271- 303.

[3] S. Lucia, T. Finkler, D. Basak, S. Engell: A new Robust NMPC Scheme and its Application to a Semi-batch Reactor Example. To appear in *Proc. Int. Symp. on Advanced Control of Chemical Processes (ADCHEM)*, 2012.