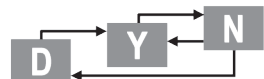


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Reinaldo Enrique Hernandez Rivas

**Contributions to Real-time Optimization
of Process Systems under Uncertainty**



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Eidesstattliche Erklärung. Statutory Declaration

Eidesstattliche Erklärung Ich erkläre an Eides statt, dass die vorliegende Dissertation in allen Teilen von mir selbständig angefertigt wurde und die benutzten Hilfsmittel vollständig angegeben worden sind.

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Abstract

Real-time Optimization (RTO) has become the standard approach for improving plant performance in many petrochemical plants. In RTO, usually a first principle-based steady-state process model is used to formulate and solve a model-based optimization problem to compute the optimal operating conditions which maximize the economic performance of the plant while satisfying safety, process, and environmental constraints. However, despite its proclaimed benefits, the implementation of model-based online optimization is still limited to relatively few cases. One of the main reasons is the issue of model-plant mismatch: By using an inaccurate model, the computed operating point will be suboptimal and, in the worst scenario, the constraints can be violated.

This dissertation attempts to overcome some of the difficulties that the process industry is currently facing in the deployment of RTO with inaccurate models. This work builds on the main idea of iterative correction of the nominal optimization problem with the estimated plant gradients according to the principle of Modifier Adaptation (MA) algorithm and provides several methodological contributions to overcome some of its limitations. First, trust-region optimization is combined with the traditional MA approach with the goal of ensuring convergence to the plant optimum under relatively mild assumptions regarding the properties of the available model. Second, a new algorithm is presented for those cases where in addition to model uncertainties, the plant measurements are contaminated with significant levels of noise. Third, two approaches to fast RTO are investigated to combine dynamic information with the available process model resulting in a faster convergence to the plant optimum. Experimental results in a miniplant for hydroformylation of long-chain alkenes showed the potential benefits of using iterative optimization for improving plant performance.

Zusammenfassung

Real-Time Optimization (RTO) hat sich zum Standard entwickelt, um die Leistung petrochemischer Anlagen zu erhöhen. Bei dem Einsatz von RTO werden normalerweise physikalisch-chemisch begründete stationäre Prozessmodelle eingesetzt, um ein modellbasiertes Optimierungsproblem zu definieren und zu lösen. Dabei wird die ökonomische Performance einer Anlage optimiert unter Einhaltung von Sicherheits-, Prozess- und Umweltauflagen. Trotz des erheblichen Nutzens ist die Anwendung von modellbasierter online-Optimierung immer noch auf wenige Fälle beschränkt. Einer der Hauptgründe dafür ist der Aufwand für die Erstellung hinreichend genauer Modelle. Wenn man ein ungenaues Modell verwendet, wird der berechnete Betriebspunkt der Anlage suboptimal sein und im schlimmsten Fall können die erwähnten Beschränkungen verletzt werden.

Diese Dissertation versucht, einige der Schwierigkeiten aus dem Weg zu räumen, die derzeit der Prozessindustrie beim Einsatz von RTO mit ungenauen Modellen bestehen. Die Arbeit baut auf der Idee einer iterativen Korrektur des nominalen Optimierungs-Problems mit geschätzten Gradienten nach dem Prinzip des Modifier-Adaptation-Algorithmus (MA) auf und beschreibt methodische Neuerungen, um den Einsatz einfacher und sicherer zu machen. Als erstes wird Trust-Region-Optimierung kombiniert mit dem traditionellen MA-Ansatz mit dem Ziel, Konvergenz mit dem Anlagen-Optimum zu erreichen unter milden Annahmen bezüglich der Eigenschaften des Modells. Zweitens wird ein neuer Algorithmus für solche Fälle vorgestellt, in denen die Betriebsmessdaten der Anlage von signifikantem Rauschen kontaminiert sind. Drittens werden zwei Ansätze für schnelle RTO untersucht, um dynamische Information mit dem vorhandenen Prozessmodell zu kombinieren, was zu einer schnelleren Konvergenz zum Anlagen-Optimum führt. Experimentelle Ergebnisse aus einer Minianlage für die Hydroformylierung langkettiger Alkene belegen die möglichen Vorteile des Einsatzes iterativer Optimierung zur Verbesserung der Anlagenleistung.

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