Texas Wisconsin California Control Consortium —
Group Highlights

James B. Rawlings

Department of Chemical and Biological Engineering
University of Wisconsin–Madison

Austin, Texas
March 5–6, 2012
1 Overview of Research Projects

2 Recent news
New project: Performance monitoring principles for model predictive control

- Ph.D. student: Luo Ji → Megan Zagrobelny
- Faculty: Edgar and Qin?
- Industrial partner: Air Products, ExxonMobil, Others?
- Funding: Submitted new NSF proposal
- Trying again with NSF GOALI with ExxonMobil
- Recent and upcoming publications:
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  Ji, L. and J. B. Rawlings.  
  MPC performance monitoring and evaluation principles.  
New project: Economic optimal control with distributed agents

- **Ph.D. students**: Cuyler Bates
- **Funding**: Submitted NSF renewal proposal (declined)
- **Funding**: Next step?
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- Faculty: Marquardt (RWTH Aachen), Angeli (Imperial), Diehl (Leuven), Biegler (CMU)
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Amrit, R., J. B. Rawlings, and D. Angeli.
Economic optimization using model predictive control with a terminal cost.

Angeli, D., R. Amrit, and J. B. Rawlings.
Enforcing convergence in nonlinear economic mpc.
Accepted for publication.

Angeli, D., R. Amrit, and J. B. Rawlings.
On average performance and stability of economic model predictive control.
Accepted for publication.

Diehl, M., R. Amrit, and J. B. Rawlings.
A Lyapunov function for economic optimizing model predictive control.

Angeli, D. and J. B. Rawlings.
Receding horizon cost optimization and control for nonlinear plants.
In *8th IFAC Symposium on Nonlinear Control Systems (NOLCOS)*. Bologna, Italy, September 2010.
Computational modeling of the growth and spread of viruses

- Ph.D. students: Rishi Srivastava, Ankur Gupta
- Faculty: John Yin (CBE)
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Nonlinear stochastic systems and moving horizon estimation

- Postdoc: Fernando Lima → Luo Ji, G. Mancuso, U. Pisa
- Industrial partner: Tyler Soderstrom, ExxonMobil
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- Recent and upcoming publications:
  
  - Rawlings, J. B. and L. Ji.  
    Submitted for publication.
  
    Covariance and state estimation of weakly observable systems: Application to polymerization processes.  
    Submitted for publication.
  
  - Lima, F. V. and J. B. Rawlings.  
    Nonlinear stochastic modeling to improve state estimation in process monitoring and control.  
Optimization of supply chains

- **Ph.D. students**: Kaushik Subramanian
- **Faculty**: Christos Maravelias (CBE)
- **Industrial partner**: Larry Megan and Jesus Flores-Cerrillo, Praxair
- **NSF GOALI proposal funded**: Optimization of the Industrial Gas Supply Chain
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Integration of control theory and scheduling methods for supply chain management.

Subramanian, K., C. T. Maravelias, and J. B. Rawlings.
Improving supply chain performance using game theory, cooperation and model predictive control.
In AIChE Annual Meeting. Salt Lake City, UT, November 2010.

Cooperation-based optimization of industrial supply chains.
Integration of control theory and scheduling methods for supply chain management

Kaushik Subramanian  James B. Rawlings  Christos T. Maravelias
Jesus Flores-Cerrillo  Lawrence Megan

Department of
Chemical and Biological Engineering

Praxair, Inc.

FOCAPO/CPC 2012
Savannah, Georgia
January 8–13, 2012
Motivation: Praxair-Steel mill supply chain

- **Scheduling model** for the steel mill
- **Inventory management** for Praxair
- Steel mill and Praxair choices are coupled
- **Cooperative** operation can reduce operating costs
In this talk...

We present results on

1. Cooperative model predictive control for inventory management
   - Tailored to fit the distributed nature of inventory management

2. State space approach to scheduling
   - Using control tools in scheduling
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as steps towards implementing MPC on a complex supply chain

- Distributed approach: each node of the supply chain makes its own decisions
- Guaranteed closed-loop properties: feasibility, stability
Detailed optimization model + rolling horizon guarantees . . .
Detailed optimization model + rolling horizon guarantees . . . no reasonable closed-loop properties!
Detailed optimization model + rolling horizon guarantees ... no reasonable closed-loop properties!

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Distributed MPC enables use of many interacting decision makers to improve overall system performance
Conclusions

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- Distributed MPC enables use of many interacting decision makers to improve overall system performance
- Current status: suboptimal MPC theory + distributed design so
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- **Distributed** MPC enables use of many interacting decision makers to improve overall system performance
- Current status: *suboptimal* MPC theory + distributed design so distributed MPC ⊂ suboptimal MPC
Future Research Directions

Distributed supply chain optimization (part I)

- Distributed restart for coupled unstable systems. Handle warm start infeasibility caused by unmodeled disturbances.
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SuRaMaFl-CeMe

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- Design rescheduling algorithms with desired closed-loop properties
- Develop surrogate models for inventory management Sung and Maravelias (2009)
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- National Science Foundation
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- Luo Ji spent the summer at ExxonMobil in Baytown (state estimation)
- Rishi Amrit accepted employment at Shell in Houston
- Luo Ji will spend next summer at Air Products
- Megan Zagrobelny will spend next summer at Eastman Chemical
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- JBR will receive the 2013 Nordic Process Control Award.