

Texas–Wisconsin Modelling and Control Consortium — Introduction

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Madison, Wisconsin
September 27–28, 2000

- Agenda
- Group Highlights
- CPC 6 Status Report
- Faculty Hiring in Systems Area



Research Areas

- Moving horizon state estimation.
 - Eric Haseltine. 2000 NSF Graduate Fellowship.
 - Chris Rao finished (postdoc in bioinformatics, Asst. Prof. at Ohio State).
- Model-based process monitoring.
Brian Odelson. Summer at Amoco.
- Model predictive control (MPC) theory and computation
 - Nonlinear model predictive control.
Matt Tenny. Writing prelim.
 - Robust model predictive control.
Jenny Wang. Passed prelim. Final year of NSF Graduate Fellowship.
- Particulate reactor modeling and control.
Daniel Patience. Passed prelim.
- Chemical vapor deposition modeling and control.
Scott Middlebrooks. Writing thesis. Industrial offers, start-up company.
- Polymerization reactor control.
Rahul Bindlish finished (Dow).
- Parameter Estimation Tools for ODE and DAE Models.
Sankash Venkatesh. Writing M.S. thesis.



Other Activities

- Octave modeling language development. John Eaton.
- Two visitors
 - Gabriele Pannocchia. Profs. Brambilla, Scali, and Semino's group, University of Pisa. Disturbance Models and Robust MPC of Ill-conditioned Processes.
 - John Bagterp Jorgensen. Prof. Sten Bay Jorgensen's group, Technical University of Denmark. Constrained Extended Linear Quadratic Regulation.
- Elected Department Chair. Three year term began in July 2000.
- 1999 Computing in Chemical Engineering Award, CAST Division, AIChE
- 1999 Van Ness Lecturer, Rensselaer Polytechnic Institute



Research Sponsors

Current Sponsors

- TWMCC members: Aspentech, DuPont, Exxon, and Equilon (Shell)
- National Science Foundation
- Department of Defense MURI program (ending)
- International Fine Particle Research Institute (IFPRI) (ending)

New Sponsors

- SmithKline Beecham / GlaxoWellcome



Model predictive control theory and computation

Rawlings, J. B. Tutorial overview of model predictive control. *IEEE Control Systems Magazine*, 20(3):38–52, June 2000.

Mayne, D. Q., J. B. Rawlings, C. V. Rao, and P. O. M. Scokaert. Constrained model predictive control: Stability and optimality. *Automatica*, 36(6):789–814, 2000.

Rao, C. V. and J. B. Rawlings. Linear programming and model predictive control. *J. Proc. Cont.*, 10:283–289, 2000.

Rao, C. V. and J. B. Rawlings. Robust model predictive control: Game theory and output feedback. Annual AIChE Meeting, Dallas, Texas, November 1999.



Moving horizon state estimation theory

Rao, C. V. and J. B. Rawlings. Constrained process monitoring: a moving horizon approach. Submitted for publication in *AIChE J*, 2000.

Rao, C. V. and J. B. Rawlings. Nonlinear moving horizon estimation. In Allgöwer, F. and A. Zheng, editors, *Nonlinear Model Predictive Control*, volume 26 of *Progress in Systems and Control Theory*, pages 45–69, Basel, 2000. Birkhäuser.

Rao, C. V., J. B. Rawlings, and D. Q. Mayne. Constrained state estimation for nonlinear discrete-time systems: Stability and moving horizon approximations. Submitted for publication in *IEEE Transactions on Automatic Control*, April 2000.

Rao, C. V., J. B. Rawlings, and J. H. Lee. Constrained linear state estimation - a moving horizon approach. Submitted for publication in *Automatica*, July 1999.

Rao, C. V. and J. B. Rawlings. Constrained process monitoring: A moving horizon perspective. Annual AIChE Meeting, Dallas, Texas, November 1999.



Particulate reactor modeling and control

Patience, D. B. and J. B. Rawlings. Particle shape monitoring and control in crystallization processes. Submitted for publication in *AIChE J*, September 2000.

Patience, D. B., H. A. Mohameed, and J. B. Rawlings. Crystallization of para-xylene in scraped-surface crystallizers. Submitted for publication in *AIChE J*, August 2000.

Rawlings, J. B. and D. B. Patience. On-line monitoring of crystal shape in crystallization processes. Annual Meeting of the International Fine Particle Research Institute, Den Haag, The Netherlands, July 2000.

Rawlings, J. B. and D. B. Patience. Authors' reply to letter to the editor. *AIChE J.*, 45(8):1842–1843, August 1999.



Chemical vapor deposition modeling and control

Middlebrooks, S. A. and J. B. Rawlings. Model Based Control of Film Growth. AFOSR/DARPA MURI Research Center Annual Program Review, Arlington, Virginia, September 2000.

Polymerization reactor modeling and control

Bindlish, R. and J. B. Rawlings. Target linearization and model predictive control of polymerization processes. Submitted for publication in *AIChE J*, 2000.

Bindlish, R., J. B. Rawlings, and R. E. Young. Parameter estimation for industrial polymerization processes. Submitted for publication in *AIChE J*, 2000.

Bindlish, R. and J. B. Rawlings. Model predictive control of a prototypical copolymerization process. Annual AIChE Meeting, Dallas, Texas, November 1999.



Other Invited Presentations

Rawlings, J. B. and C. V. Rao. The dual problem of moving horizon estimation. Department of Automatic Control, Lund Institute of Technology, Lund, Sweden, June 20, 2000.

Tenny, M. J. and J. B. Rawlings. Implementing nonlinear models: algorithms and examples. Department of Automatic Control, Lund Institute of Technology, Lund, Sweden, June 16, 2000.

Jorgensen, J. B. and J. B. Rawlings. Tracking and infeasibility in model predictive control. Department of Automatic Control, Lund Institute of Technology, Lund, Sweden, June 16, 2000.

Pannocchia, G. and J. B. Rawlings. Disturbance models, offset and robustness in model predictive control. Department of Automatic Control, Lund Institute of Technology, Lund, Sweden, June 15, 2000.

Rawlings, J. B. An overview of model predictive control. Department of Automatic Control, Lund Institute of Technology, Lund, Sweden, June 15, 2000.



Other Invited Presentations

Rawlings, J. B. Real-time monitoring and control of complex product properties: Controlling the shape and size of growing crystals. UWPREL Research Conference, Madison, Wisconsin, June 5, 2000.

Rawlings, J. B. Computing and chemical engineers: More or less. CAST Division Awards Dinner, AIChE Meeting, Dallas, Texas, November 2, 1999.

Rawlings, J. B. Modeling and control of silicon and germanium thin film chemical vapor deposition. Van Ness Lecture, Department of Chemical Engineering, Rensselaer Polytechnic Institute, Troy, New York, October 27, 1999.

Rawlings, J. B. Computing and the education of chemical engineers: More or less. Van Ness Lecture, Department of Chemical Engineering, Rensselaer Polytechnic Institute, Troy, New York, October 26, 1999.



Merging Octave with a Scripting Language

Possible choices:

- Guile: GNU embeddable Scheme interpreter with object-oriented extensions.
- Python: a widely used object-oriented scripting language.

By merging with another well-known scripting language, we can concentrate on building numerics while taking advantage of general purpose tools (graphics, GUIs, web applications, etc.) already built by others for these languages.

Plan (if Guile is used):

- Make Octave's numerical core available to Guile.
- Replace Octave's interpreter with Guile.
- Allow Guile functions to be called from Octave.



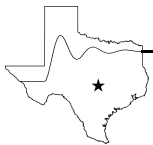
Guile developers and users are enthusiastic about the possibilities:

- I think this would be superb — a great benefit to both tools.
—Jim Blandy <jimb@savonarola.red-bean.com>
- Adding Guile to Octave could be a great move!
For me, octave is one of the cornerstones of my computing environment . . . One small example of how great it is that I rarely write stand alone ODE codes anymore . . .
—John Daschbach <John.Daschbach@pnl.gov>
- As a heavy matlab user, I'd also like to see this. A translator for the matlab language would be nice, but a cleaned up matlab-type language which is internally translated to scheme would be even nicer.
—Michael Vanier <mvanier@bbb.caltech.edu>
- I think Octave and Guile would fit perfectly.
—Marius Vollmer <mvo@zagadka.ping.de>
- I considered looking into it myself, back when I had a lot more time for playing with the code. It looked like the obvious Right Thing to do.
—Miroslav Silovic <silovic@zesoi.fer.hr>



CPC 6 Update

- What: Chemical Process Control 6
- When: January 7–12, 2001
- Where: Westward Look Resort, Tucson, Arizona
- Co-Chairs: James B. Rawlings, University of Wisconsin
Babatunde A. Ogunnaike, DuPont
- Registration:
Before Oct. 3, Earlybird fee – \$675
Oct. 3 to Dec. 15, Regular fee – \$800
- Latest details: <http://www.che.wisc.edu/cpc-6/>



Chemical Process Control: CPC 6

Program

Session Topic (Organizer)

Sunday evening

* Opening Session (J. Brian Froisy)

Author: Lowell B. Koppel, Value Techniques LLC
Title: Business Process Control: The Outer Loop

Author: J. Patrick Kennedy, OSI Software
Title: Influence of Computers and Information Technology on
Process Operations and Business Processes - A Case
Study

Monday morning

* Modeling and Identification (Jay H. Lee)

Author: Wolfgang Marquardt, RWTH Aachen
Title: Modeling for Control -or- Model Reduction for Control
Discussant: Thomas A. Badgwell, AspenTech

Author: Ton Backx, IPCOS Technology
Title: System Identification: State of the Art and Current
Needs - Industrial Perspective
Discussant: Daniel Rivera, Arizona State University

Author: Sten Bay Jorgensen (speaker), Technical Univ. Denmark,
Jay H. Lee, Georgia Institute of Technology
Title: Recent Advances and Challenges in Process
Identification - Academic Perspective
Needs - Academic Perspective
Discussant: John F. MacGregor, McMaster University

Panel Discussion: Fundamental modeling vs. system
identification (What are the merits
and demerits? What's the role of
large, nonlinear fundamental models in
control? How can the two be merged?)

Panelists: Three speakers. Moderated by the organizer.

Monday evening

* Life Sciences (Francis J. Doyle)

Author: Adam Arkin, Univ. California, Lawrence Berkeley
National Laboratory
Title: Stochastic and Deterministic Control in Two Bacterial
Cellular Networks

Discussant: James Schwaber, Thomas Jefferson University



Chemical Process Control: CPC 6

Meeting Date

January 7-12, 2001 at the Westward Look Resort in Tucson Arizona.

Co-Chairs

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Faculty Hiring in Systems Area

- Cluster hiring initiative in computational sciences
- **Steve Wright** applied and interviewed on campus September 7. Potential tenure home in Computer Science Department.

