# RESUME

| | | |
|---|---|---|
| *Name* | **:** | **Sachin C. Patwardhan** |
| *Designation* | **:** | Professor |
| *Address* | **:** | Department of Chemical Engineering, |
| | | Indian Institute of Technology Bombay, |
| | | Powai, Mumbai, 400 076, India |
| | | Tel. : +91-22-2572 7211 / +91-22-2572 7200 (O) |
| | | Fax : +91-22-2572 6895 |
| *Email* | **:** | sachinp@iitb.ac.in |

## Academic Record

| Course | Institute | Specialization | Year |
|---|---|---|---|
| B. Tech. | Institute of Technology, Banaras Hindu University, Varanasi 221005 | Chemical Engineering | 1986 |
| M. Tech. | Indian Institute of Technology, Madras 600 036 | Process Control and Instrumentation | 1988 |
| Ph. D. | Indian Institute of Technology, Powai, Bombay 400 076 | Systems and Control Engineering | 1994 |

## Areas of Research

- Control relevant dynamic modeling of nonlinear systems
- Nonlinear model predictive control
- On-line fault diagnosis and fault tolerant control
- Nonlinear Bayesian state estimation and particle filtering
- Adaptive control of Chemical and Bio-chemical Processes

## Visiting Assignments

| No | University | Designation | From       To |
|---|---|---|---|
| 1 | Dept. of Chemical Engineering, Carnegie Mellon University, U.S.A. | Visiting Research Scholar | 15.08.08      31.05.09 |
| 2 | Dept. of Chemical and Materials Engineering, University of Alberta, Canada | Visiting Professor | (a) 3.12.2000 - 11.11.2001 (b) 6.5.2004 – 10.7.2004 (c) 1.5.2007 – 30.6.2007 |
| 3 | Technical University of Munich, Germany | Visiting Professor | (a) 15.5.1998 – 25.7.1998 (b) 16.5.1999 – 15.7.1999 |

**Awards**

1. Indira Manudhane Best Post Graduate Teacher Award in Chemical Engineering, 2004-2005.
2. Manudhane Award for Best Applied Research in Chemical Engineering, 2003.

## List of Publications

**International Journals**

1. Kiasi, F., Prakash, J., Patwardhan, S. C., Shah, S. L., "A Unied Framework for Fault Detection and Isolation of Sensor and Actuator Biases in Linear Time Invariant Systems using Marginalized Likelihood Ratio Test and Uniform Priors", *Journal of Process Control,* 23, 1350– 1361, **2013**.
2. Purohit, J., Patwardhan, S.C., Mahajani, S., "DAE EKF Based Nonlinear Predictive Control of Reactive Distillation Systems Exhibiting Input and Output Multiplicities", *Industrial and Engineering Chemistry Research,* 52, 13699−13716, **2013**.
3. Purohit, J., Mahajani, S., Patwardhan, S.C., "Analysis of steady state multiplicity in reactive distillation columns", *Industrial and Engineering Chemistry Research,* 52, 5191−5206, **2013**.
4. Huang, R., Patwardhan, S. C., Biegler, L. T., Robust stability of nonlinear model predictive control with extended Kalman Filter and target setting. *Int. J. of Robust and Nonlinear Control,* 23, 1240–1264, **2013**.
5. Patwardhan, S. C., Narasimhan, S., Prakash, J., Gopaluni, R.B., Shah, S. L., "Nonlinear Bayesian State Estimation: Review And Recent Trends", *Control Engineering Practice,* 20, 933–953, **2012**.
6. Detroja, K, Gudi, R. D., Patwardhan, S. C., Data reduction algorithm based on principle of distributional equivalence for fault diagnosis, *Control Engineering Practice,* 20, 1033–1041, **2012.**
7. Bavdekar, V. A. and Patwardhan, S. C., "Development of Grey Box State Estimators for Systems Subjected to Time Correlated Unmeasured Disturbances", *Journal of Process Control, 22, 1543– 1558,* **2012**.
8. Huang, R., Patwardhan, S. C., Biegler, L. T., Robust nonlinear model predictive control based on discrete nonlinear extended observers. *Journal of Process Control, 22, 82– 89,* **2012**.
9. Badwe, A., Patwardhan, S. C., Gudi. R. D., Closed-loop Identification Using Direct Approach and high order ARX / OBF-ARX Models. *Journal of Process Control,* 21, 1056– 1071, **2011**.
10. López-Negrete, R., Patwardhan, S. C., Biegler, L. T. , Approximation of Arrival Cost in Moving Horizon Estimation Using a Constrained Particle Filter, *Journal of Process Control,* 21, 909–919, **2011**.
11. Bavdekar, V. A., Deshpande, A. P., and S. C. Patwardhan, Identification of Process and Measurement Noise Covariance for State and Parameter Estimation Using Extended Kalman Filter. *Journal of Process Control,* 21, 585–601, **2011**.
12. Prakash, J., Patwardhan, S. C., Shah, S. L. On The Choice Of Importance Distributions For Unconstrained and Constrained State Estimation Using Particle Filter, *Journal of Process Control,* 21, 3–16, **2011**.
13. Kumar, S., Narasimhan, K., Patwardhan, S. C., and Prasad, V., Extensions To Experiment Design And Identification Algorithms For Large-Scale And Stochastic Processes. *International Journal of Advanced Mechatronics System,* 3, 1, 3-13, **2011**.

14. Huang, R., Patwardhan, S. C., Biegler, L. T. , Stability of a Class of Discrete Nonlinear Extended Observers. *Journal of Process Control, 20, 1150–1160,* **2010**.

15. Prakash, J., Patwardhan, S. C., Shah, S. L. State Estimation and Nonlinear Predictive Control of Autonomous Hybrid System Using Derivative Free State Estimators. *Journal of Process Control,* 20, 787–799, **2010**.

16. Badwe, A., Singh, A., Patwardhan, S. C., Gudi. R. D., A Constrained Recursive Pseudo-linear Regression Scheme for On-line Parameter Estimation in Adaptive Control. *Journal of Process Control,* 20, 559–572, **2010**.

17. Huang, R., Biegler, L. T., Patwardhan, S. C., Offset-free Advanced Step Nonlinear Model Predictive Control Based on Moving Horizon Estimation, *Ind. Eng. Chem. Res.,* 49, 7882–7890., **2010**.

18. Prakash, J., Patwardhan, S. C., Shah, S. L. Constrained Nonlinear State Estimation Using Ensemble Kalman Filter. *Ind. Eng. Chem. Res.*, 49, 2242–2253, **2010**.

19. Methekar, R. N., Patwardhan, S. C., Rengasamy, R., Gudi, R. D., Prasad, V. Control of PEMFC using Data Driven State Space Models, *Chem. Eng. Res. Des.,* Dec., doi:10.1016/j.cherd.2009.12.00, **2010**.

20. Methekar, R. N., Patwardhan, S. C., Gudi, R. D., Prasad, V. Adaptive Peak Seeking Control of a Proton Exchange Membrane Fuel Cell. *Journal of Process Control, 20, 73–82,* **2010**.

21. Deshpande, S., Patwardhan, S. C., Methekar, R., Rengasamy, R. Unconstrained NMPC Based on a Class of Weiner Models: A Closed Form Solution. *Ind. Eng. Chem. Res.*, 49, 148–165, **2010**.

22. Badwe, A., Shah, S. L., Patwardhan, R. S., Patwardhan, S. C., Gudi. R. D., Quantifying the impact of model-plant mismatch on controller performance. *Journal of Process Control,* 20, 408–425, **2010**.

23. Muddu, M., Anuj Narang, A., Patwardhan, S. C., Reparameterized ARX Models for Predictive Control of a Distillation Column, *Control Engineering Practice*, 18, 114–130, **2010**.

24. Tufa, L. D., Ramasamy, M., Patwardhan, S. C., Shuhaimi, M., Development of Box-Jenkins type Time Series Models by Combining Conventional and Orthonormal Basis Filter Approaches. *Journal of Process Control,* 20, 108–120, **2010**.

25. Muddu, M., Anuj Narang, A., Patwardhan, S. C., Development of ARX models for Predictive Control using Fractional Order and Orthonormal Basis Filter Parameterization, *Ind. Eng. Chem. Res.*, 48, 8966–8979, **2009**.

26. Badwe, A., Gudi. R. D., Shah, S. L., Patwardhan, R. S., Patwardhan, S. C., Detection of Model-Plant Mismatch in MPC Applications, *Journal of Process Control,* 19, 1305–1313, **2009**.

27. Deshpande, A., Patwardhan, S. C., Narasimhan, S. Intelligent State Estimation for Fault Tolerant Nonlinear Model Predictive Control, *Journal of Process Control,* 19, 187–204, **2009**.

28. Manuja, S.; Patwardhan, S.C. ; Narasimhan, S.; Unknown Input Modeling and Robust Fault Diagnosis using Black Box Observers., *Journal of Process Control,* 19, 25–37, **2009**.

29. Deshpande, A., Zamad, U., Patwardhan, S. C., On-line Sensor / Actuator Failure Isolation and Reconfigurable Control using Generalized Likelihood Ratio Method, *Ind. Eng. Chem. Res.*, 48, 1522-1535, **2009**.

30. Deshpande, A., Patwardhan, S. C. Online Fault Diagnosis in Nonlinear Systems using Multiple Operating Regime Approach, *Ind. Eng. Chem. Res.,* **2008**, 47, 6711–6726.

31. Srinivas, K., Shaw, R., Patwardhan, S. C., Noronha, S. Adaptive model predictive control of multivariable time-varying systems. *Ind. Eng. Chem. Res.*, **2008**, 47, 2708-2720.
32. Thornhill, N., Patwardan, S. C., Shah. S. L. A continuous stirred tank heater simulation model with applications, *Journal of Process Control*, **2008,** 18, 347–360.
33. Manuja, S.; Narasimhan, S.; Patwardhan, S. C. ; Fault Diagnosis and Fault Tolerant Control Using Reduced Order Models., *Canadian Journal of Chemical Engineering,* 86, 4, **2008,** 791-803**.**
34. Detroja, K. P. ; Gudi, R. D., Patwardhan, S. C., Plant-wide detection and diagnosis using correspondence analysis, *Control Engineering Practice,* 15, 1468–1483, **2007**.
35. Yamunarani, K. ; Patwardhan, S. C. Data-driven model based control of a multi-product semi-batch polymerization reactor. *Trans IChemE, Part A, Chemical Engineering Research and Design*, **2007**, 85(A10), 1397–1406.
36. Srinivasarao,M.; Patwardhan,S. C.; Gudi, R. D. Nonlinear predictive control of irregularly sampled multi-rate systems using nonlinear black box observers. *Journal of Process Control*, **2007**, 17, 17–35.
37. Detroja, K. P. ; Gudi, R. D., Patwardhan, S. C. A possibilistic clustering approach to novel fault detection and isolation, *Journal of Process Control,* **2006,** 16, 1055-1073.
38. Srinivasrao, M.; Patwardhan, S.C. ; Gudi, R. D. From data to nonlinear predictive control. 2.. Improving regulatory performance using identified observers. *Ind. Eng. Chem. Res.,* **2006,** 45, 3593-3603**.**
39. Srinivasrao, M.; Patwardhan, S.C. ; Gudi, R. D. From data to nonlinear predictive control. 1. Identification of multivariable nonlinear state observers. *Ind. Eng. Chem. Res.,* **2006,** 45, 1989-2001**.**
40. Detroja, K. P. ; Gudi, R. D.; Patwardhan, S. C.; Roy, K. Fault detection and isolation using correspondence analysis. *Ind. Eng. Chem. Res.*, **2006**, 45, 223-235.
41. Patwardhan, S.C. ; Manuja, S.; Narasimhan, S.; Shah, S. L From data to diagnosis and control using generalized orthonormal basis filters. Part II: Model predictive and fault tolerant control. *Journal of Process Control*, **2006**, 16, 157–175.
42. Patwardhan, S.C. ; Shah, S. L. From data to diagnosis and control using generalized orthonormal basis filters. Part I: Development of state observers. *Journal of Process Control*, **2005**, 15, 819–835.
43. Prakash, J.; Patwardhan, S. C.;Narasimhan, S. Integrating model based fault diagnosis with model predictive control. *Ind. Eng. Chem. Res.*, **2005**, 44, 4344-4360.
*44.* Rani, K. Y. ; Patwardhan, S. C. Data-driven modeling and optimization of semi-batch reactors using artificial neural networks. *Ind. Eng. Chem. Res.,* **2004**, 43, 7539-7551.
45. Saha, P.; Krishnan, S. H. ; Rao, V. S. R. ; Patwardhan, S. C. Modeling and predictive control of MIMO nonlinear systems using Weiner-Laguerre models. *Chemical Engineering Communications*, **2004**, 191, 1083-1119.
46. Prakash, J.; Patwardhan, S. C.;Narasimhan, S. A supervisory approach to fault tolerant control of linear multivariable systems. *Ind. Eng. Chem. Res.,* **2002**, **41**, 2270-2281.
47. Kishore, K. K.; Patwardhan, S. C. "Nonlinear predictive control of systems exhibiting input multiplicities using multi-model approach. *Ind. Eng. Chem. Res.,* **2002**, 41, 3186-3198.
48. Saha, P.; Patwardhan, S. C.; Rao, V. S. R. Adaptive optimizing control of continuous fermenter using nonlinear Laguerre models", *Bioprocess Engineering,* **1999**, 20, 1, 15-21.

4

49. Patwardhan, S. C.; Madhavan, K.P.  Nonlinear internal model control using quadratic prediction models.  *Computers and Chem. Engng.,* **1998**, 22, 4/5, 587-601.

50. Patwardhan, S. C.; Madhavan, K.P. Improved techniques for development of quadratic perturbation models. *Ind. Eng. Chem. Res.***, 1996**, 35, 4281-4290.

51. Patwardhan, S. C.; Madhavan, K.P.  Nonlinear predictive control using approximate second order perturbation models. *Ind. Eng. Chem. Res.*, **1993**, 32, 334.

## Journal Manuscripts Under Review

1. Bavdekar, V. A., Nandola, N., Patwardhan, S. C., "Estimation of Noise Covariance Matrices for State Estimation of Autonomous Hybrid Systems", Submitted to *Control Engineering Practice,* Jan.,2013.

## Book Chapters

1. Deshpande, S.,  Patwardhan, S. C., Unconstrained NMPC Based on a Class of Weiner Models: A Closed Form Solution, in *Nonlinear Model Predictive Control,* Magni, L., Raimondo; D. M.; Allgöwer, F.  (Eds.), *Lecture Notes in Control and Information Sciences,* **2009**, pp 481-480, Springer, Berlin.

2. Prakash, J., Deshpande, A. P., Patwardhan, S. C., State Estimation and Fault Tolerant Nonlinear Predictive Control of an Autonomous Hybrid System Using Unscented Kalman Filter. in *Nonlinear Model Predictive Control,* Magni, L., Raimondo; D. M.; Allgöwer, F.  (Eds.), *Lecture Notes in Control and Information Sciences,* **2009**, pp 285-293, Springer, Berlin.

3. López-Negrete, R., Patwardhan, S. C.,  Biegler, L. T. , Approximation of Arrival Cost in Moving Horizon Estimation Using a Constrained Particle Filter, *Elsevier Series on Computer Aided Chemical Engineering*, 27, 1299-1304, **2009.**

4. Huang, R.,  Patwardhan, S. C.,  Biegler, L. T. , Robust output-feedback nonlinear model predictive control using high-gain observers, *Elsevier Series on Computer Aided Chemical Engineering*, 27, 1611-1616, **2009.**

5. Huang, R.,  Patwardhan, S. C.,  Biegler, L. T. , Multi-scenario-based robust nonlinear model predictive control with first principle models, *Elsevier Series on Computer Aided Chemical Engineering,* 27, 1293-1298, **2009.**

6. Srinivasarao, M., Patwardhan, S. C.; Gudi, R. D. Nonlinear Predictive Control of Irregularly Sampled Nonlinear Systems Using Identified Observers, *In Assessment and Future Directions of Nonlinear Model Predictive Control*, Findeisen, R., Allgower, F. Biegler, L. T. (Eds.), *Lecture Notes in Control and Information Sciences,* **2007,** pp. 141-150**,** Springer, Berlin.

7. Deshpande, A.; Patwardhan, S. C., Narasimhan, S. Integrating fault diagnosis with nonlinear model  predictive control. *In Assessment and Future Directions of Nonlinear Model Predictive Control*, Findeisen, R., Allgower, F. Biegler, L. T. (Eds.), *Lecture Notes in Control and Information Sciences,* **2007,** 513-522, Springer, Berlin.

8. Munawar, S.A.  ; Kapadi, M. D.; Patwardhana, S.C.  ; Madhavan, K.P.  ; Pragathieswaranb, S.; Lingathurai, P.; Gudi, R. D.  Integration of planning and scheduling in multi-site plants: Application to paper manufacturing. *Elsevier Series on Computer Aided Chemical Engineering*, 20, 2, 1621-1626, **2005**.

**Proc. of Reviewed International Conferences**

1. Muddu M., Patwardhan, S. C., Adaptive Predictive Control using GOBF-ARX Models: An Experimental Case Study, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems* (*DYCOPS-2013*) , Mumbai, India, 18-20 Dec., 2013.
2. Deshpande, S. S., Patwardhan, S. C., Computationally Efficient Globally Linearizing Control of a CSTR using Nonlinear Black Box Models, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems* (*DYCOPS-2013*) , Mumbai, India, 18-20 Dec, 2013.
3. Purohit, J., Patwardhan, S. C., Mahajani, S. M., Predictive Control of a Reactive Distillation Column using Multi-rate DAE EKF, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems* (*DYCOPS-2013*) , Mumbai, India, 18-20 Dec, 2013.
4. Huang, R., Patwardhan, S. C., Biegler, L. T. , One way separation principle for a class of nonlinear observers and the robust stability analysis, *Proc. of 4th IFAC Nonlinear Model Predictive Control Conference,* Noordwijkerhout, Netherlands, August 23-27, 2012.
5. Deshpande, S., Joy, P., and Patwardhan, S. C., Computationally Efficient Globally Linearizing Control of a CSTR and the Tennessee Eastman Problem using Quadratic Perturbation Models, *Proc. of American Control Conference 2012,* Montreal, Canada, June 27-29, 2012.
6. Puranik, Y., Bavdekar, V. A., Patwardhan, S. C. and Shah, S. L.*,* An Ensemble Kalman Filter for Systems Governed by Differential Algebraic Equations (DAEs), *Proc. of 8th IFAC Symposium on Advanced Control of Chemical Processes,* Singapore, July 10-13, 2012.
7. Bavdekar, V. A., Shah, S. L.*,* and Patwardhan, S. C., Perspectives on State Estimation: Spot Estimates Versus Distributions. *Proc. of 8th IFAC Symposium on Advanced Control of Chemical Processes,* Singapore, July 10-13, 2012.
8. Parikh N. S., Patwardhan, S. C. and Gudi, R. D., "Closed loop Identification of Quadruple Tank System using an Improved Indirect Approach", *Proc. of 8th IFAC Symposium on Advanced Control of Chemical Processes,* Singapore, July 10-13, 2012.
9. Bavdekar, V. A. and Patwardhan, S. C., "Development of grey-box unscented Kalman filter for systems subjected to correlated unmeasured disturbances", *Proc. of International Symposium on Advanced Control of Industrial Processes*, pp. 343-348, Hangzhou, China, 23-26 May, 2011.
10. Detroja, K, Gudi, R. D., Patwardhan, S. C.*,* "Data Reduction and Fault Diagnosis Using Principle of Distributional Equivalence", *Proc. of International Symposium on Advanced Control of Industrial Processes*, pp. 30-35, Hangzhou, China, 23-26 May, 2011.
11. Muddu, M., Patwardhan, S. C., "Adaptive Predictive Control of a High Purity Distillation Column Using Irregularly Sampled Multi-rate Data" *Proc. of International Symposium on Advanced Control of Industrial Processes*, pp. 30-35, Hangzhou, China, 23-26 May, 2011.
12. Parikh, N., Patwardhan, S. C., Bandyopadhyay, S., "Control of a Nuclear Steam Generator using Feedback-Feedforward LQG Controller", *Proc. of International Symposium on Advanced Control of Industrial Processes*, pp. 415-420, Hangzhou, China, 23-26 May, 2011.
13. Prakash, J., Gopaluni, R.B., Patwardhan, S. C., Narasimhan, S., Shah, S. L., "Nonlinear Bayesian State Estimation: Review And Recent Trends", *Proc. of*

*International Symposium on Advanced Control of Industrial Processes*, pp. 415-420, Hangzhou, China, 23-26 May, 2011.

14. Prakash, J., Patwardhan, S. C., Shah, S. L., "Design and Implementation Fault Tolerant Model Predictive Control Scheme on a Simulated Model of a Three-Tank Hybrid System", *Proc. of 2010 Conference on Control and Fault Tolerant System,* Nice, France, October 6-8, 2010.

15. Bavdekar, V., Patwardhan, S. C., Development Of A Grey Box Observer for a Distillation Column, *The Fifth International Symposium on Design, Operation and Control of Chemical Processes (PSE-ASIA 2010), Singapore, 25-28 July, 2010.*

16. Purohit, J., Patwardhan, S. C., Mahajani, S. M., Nonlinear Predictive Control Of Ideal Reactive Distillation Column Exhibiting Multiplicities. *The Fifth International Symposium on Design, Operation and Control of Chemical Processes (PSE-ASIA 2010), Singapore, 25-28 July, 2010.*

17. Dasgupta, D., Patwardhan, S. C.,, Development Of Block Oriented Nonlinear Time-Series Models for a Continuous Fermenter*, The Fifth International Symposium on Design, Operation and Control of Chemical Processes (PSE-ASIA 2010), Singapore, 25-28 July, 2010.*

18. Kumar, S., Narasimhan, K., Patwardhan, S. C., and Prasad, V., Experiment Design, Identification And Control In Large-Scale Chemical Processes, *Proc. of the 2010 International Conference on Modeling, Identification and Control (ICMIC)*, Okayama City, Japan, July 17-19, 2010.

19. Huang, R., Patwardhan, S. C., Biegler, L. T. , Offset-free Nonlinear Model Predictive Control Based on Moving Horizon Estimation for an Air Separation Unit, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS-2010), Leuven, Belgium, 5-7 July, 2010.*

20. Huang, R., Patwardhan, S. C., Biegler, L. T. , Adaptive Quasi-Infinite Horizon NMPC of a Continuous Fermenter , *Proc. of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS-2010) , Leuven, Belgium, 5-7 July, 2010.*

21. Bavdekar, V., Patwardhan, S. C., Identification of Noise Covariances for State Estimation of a Continuous Fermenter Using Extended EM Algorithm, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS-2010) , Leuven, Belgium, 5-7 July, 2010.*

22. Dasgupta, D., Patwardhan, S. C., NMPC of a Continuous Fermenter Using Wiener-Hammerstein Model Developed from Irregularly Sampled Multi-Rate Data , *Proc. of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS-2010) , Leuven, Belgium, 5-7 July, 2010.*

23. Huang, R., Patwardhan, S. C., Biegler, L. T. , Robust Extended Kalman Filter Based Nonlinear Model Predictive Control Formulation. *48th IEEE Conference on Decision and Control*, Shanghai, China, December 16-18, 2009.

24. Methekar R. N., Patwardhan S. C., Rengasamy R., Gudi R. D., Prasad V., Experimental evaluation of linear model based control strategies for PEMFCs, *Proc. of the 2009 American Control Conference,* June, 2009.

25. Prakash, J., S. C. Patwardhan and S. L. Shah* "Constrained State Estimation Using the Ensemble Kalman Filter", *Proc. of the 2008 American Control Conference,* Seattle, June 2008. **(Winner of the best paper in the session award.)**

26. Prakash, J., Patwardhan, S. C., On-line Sensor Fault Identification in an Autonomous Hybrid System using Likelihood Ratio Approach. *Proc. of Int. Symposium on Advanced Control of Industrial Processes (AdCONIP'08),* Jasper, Canada, May 4-6, 2008.

27. Muddu, M., Narang, A., Patwardhan, S. C. Development of Control Relevant Reparameterized ARX Models for a Packed Bed Distillation Column. *Proc. of Int. Symposium on Advanced Control of Industrial Processes (AdCONIP'08),* Jasper, Canada, May 4-6, 2008.

28. Badwe, A., Patwardhan, R. S., Patwardhan, S. C., Gudi, R. D. Quantifying the Impact of Model-Plant Mismatch on Controller Performance: A non-invasive approach. *Proc. of Int. Symposium on Advanced Control of Industrial Processes (AdCONIP'08),* Jasper, Canada, May 4-6, 2008.

29. Prakash, J., Patwardhan, S. C., Shah, S. L. Control of an autonomous hybrid system using a nonlinear model predictive controller, *Proc. of the 17th World Congress, The International Federation of Automatic Control*, Seoul, Korea, July 6-11, 2008.

*30.* Prakash, J., Patwardhan, S. C., Shah, S. L. Constrained state estimation using particle filters, *Proc. of the 17th World Congress, The International Federation of Automatic Control*, Seoul, Korea, July 6-11, 2008.

31. Badwe, A., Shah, S. L., Patwardhan, R. S., Patwardhan, S. C., Model-plant mismatch detection in mpc: applications using partial correlation analysis, *Proc. of the 17th World Congress, The International Federation of Automatic Control*, Seoul, Korea, July 6-11, 2008.

32. Prakash, J., Patwardhan, S. C., Shah, S. L. Soft sensing and state estimation: Review and recent trends. *Proc. of IFAC Conference on Cost Effective Automation in Networked Product Development and Manufacturing (IFAC-CEA 2007),* Monterrey, Mexico, 3-5 Oct., 2007.

33. Deshpande, S., Kalpana, N., Bedi, P. S., Patwardhan, S. C., Peak Seeking Control using OBF-Wiener Model Based Nonlinear IMC Scheme, *Proc. of International Conference on Control, Automation and Systems 2007*, Oct. 17-20, 2007 in COEX, Seoul, Korea

34. Zamad, U. S., Deshpande, A., Patwardhan, S. C., LQG control with reconfigurable state estimator under sensor and actuator failures, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS-2007),* Cancun, Mexico, 2-5 June, 2007.

35. Bedi, P. S., Methekar, R., Patwardhan, S. C., Prasad, V., Gudi, R. D. Nonlinear internal model control of PEM fuel cell, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems DYCOPS-2007,* Cancun, Mexico, 2-5 June, 2007..

36. Palnitkar, K., Badwe, A., Patwardhan, S. C., Gudi, R. MPC relevant identification using Generalized orthonormal basis filters, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS-2007),* Cancun, Mexico, 2-5 June, 2007..

37. Singh, A., Badwe, A., Patwardhan, S. C. Constrained recursive parameter estimation for adaptive control, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS-2007),* Cancun, Mexico from 2-5 June, 2007..

38. Palpandi, R., Badwe, A., Patwardhan, S. C., Noronha, S. Adaptive Model Predictive Control of Dissolved Oxygen in a Bioreactor, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS-2007),* Cancun, Mexico, 2-5 June, 2007..

39. Gandhi, R., Patwardhan, S. C., Shah, S. L., Identification of Non-uniformly Sampled Multirate Systems using Orthonormal Basis Filters, *Proc. of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS-2007),* Cancun, Mexico, 2-5 June, 2007..

40. Patwardhan, S. C., Narasimhan, S., Shah, S. L. Active Fault Tolerant Control using Innovation form of State Space Models, *Proc. of European Control Conference-200,* Kos, Greece from 2-5 July, 2007.

41. Detroja, K. P. ; Gudi, R. D., Patwardhan, S. C. Diagnosis of faults with varying intensities using possibilistic clustering and fault lines. *Proc. of IFAC International Symposium on Advanced Process Control of Chemical Processes – 2006 (ADCHEM'06)*, Gramado, Brazil, April, 2006.

42. Detroja, K. P. ; Gudi, R. D., Patwardhan, S. C. Fault detection using correspondence analysis: Aplication to Tenessee Eastman challenge problem, *Proc. of IFAC International Symposium on Advanced Process Control of Chemical Processes – 2006 (ADCHEM'06)*, Gramado, Brazil, April, 2006.

43. Detroja, K. P. ; Gudi, R. D., Patwardhan, S. C. Nonlinear scaling and its effects on PCA based fault detection and diagnosis. *Proc. of 16'th IFAC World Congress*, Praha, Check republic, July 2005.

44. Srinivasarao,M.; Patwardhan,S. C.; Gudi, R. D. Identification of fast-rate nonlinear Output Error models from multi-rate data. *Proc. of 16'th IFAC World Congress*, Praha,Check republic, July 2005.

45. Srinivasarao, M.; Venkatsubramanian, R.; Patwardhan S.C., "Identification of Nonlinear Observers For Multivariable Systems subjected to Unmeasured Disturbances", *Proceedings of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS 7)*, Massachusetts, U.S.A. 2004.

46. Manuja, S.; Patwardhan S.C.; Narasimhan S., "Fault Diagnosis and Fault Tolerant Control Using Reduced Order Models", *Proceedings of IFAC Symposium on Dynamics and Control of Process Systems (DYCOPS 7)*, Massachusetts, U.S.A. d uring 5-7 July, 2004.

47. Patwardhan, S.C.; Manuja, S.; Narasimhan, S., Shah, S.L.; "Online Diagnosis and Reconstruction of a Biased Sensor Using State Observer Identified From Input Output Data", *Proc. Of Int. Symposium on Advanced Control of Industrial Processes AdCONIP'02,* Kumamoto, Japan, pp 239-244, 9-12 June, 2002.

48. Patil, P.; Patwardhan, S.C.; "Regulatory Control of a CSTR at an Unstable Operating Point Using Nonlinear Internal Model Controller", *Proc. Of Int. Symposium on Advanced Control of Industrial Processes AdCONIP'02,* Kumamoto, Japan, pp 593-598, 9-12 June, 2002.

49. Patwardhan, S. C. and Madhavan, K. P. "Nonlinear Predictive Control of a Exothermic CSTR Using Recursive Quadratic State Space Models," *Proc. of The Fourth IEEE Conference on Control Applications*, Albany, New York, (1995).

**International Conference Presentations**

50. López-Negretea, R., Patwardhan, S. C., Biegler, L. T., Estimation of the Arrival Cost in MHE Using Particle Filters. *AIChE Annual Meeting*, Nashville, USA on 8-13 Nov., 2009.

51. Huang, R., Patwardhan, S. C., Biegler, L. T., Nonlinear Observer Based Robust And Offset-Free Nonlinear Predictive Control Of Air Separation Unit In A Power Plant. *AIChE Annual Meeting*, Nashville, USA on 8-13 Nov., 2009.

52. Huang, R., Patwardhan, S. C., Biegler, L. T., Online Model Maintenance And Robust Adaptive Nonlinear Model Predictive Control. *AIChE Annual Meeting*, Nashville, USA on 8-13 Nov., 2009.

*53.* Methekar, R., Prasad, V., Patwardhan, S. C., Gudi, R. D., Control of PEMFC Using Empirical Dynamic Models in An Imc and LQG Framework, *presented at AIChE National Meeting,* Nov. 4 -9, 2007, Salt Lake City, U.S.A.

54. Manuja, S.; Patwardhan S.C.; Narasimhan S., "Fault Tolerant Control with Identified Models: An Experimental Case Study", *Int. Conference on Intelligent Sensing and Information Processing ICISIP'04*, Chennai, January, 2004.
55. Manuja, S.; Narasimhan, S.; Patwardhan, S.C.; "Isolation of Abrupt Changes in Unmeasured Disturbances Using Identified State Space Models", *Proc. Of Int. Symposium on process Systems Engineering and Control* (*ISPSEC'03*)*,* Mumbai, India, pp 157. 2003.
56. Manuja, S.; Patwardhan S. C.; Narasimhan, S.; Shah, S.L.; "Fault Tolerant Control of A Distillation Column Using Optimal State Observer Identified From Input-Output Data"**,** *presented at CSChE National Meeting*, Halifax, Canada, 14-17 Oct., 2001.
57. Patil, P.; Patwardhan, S. C.; "Nonlinear Inferential Control of a CSTR Exhibiting Input Multiplicity Using Quadratic perturbation Model"**,** *presented at CSChE National Meeting*, Halifax, Canada, 14-17 Oct., 2001.
58. Yamuna Rani K ; Rao, V. S. R.; Patwardhan, S. C.; "Data Driven Modeling for Operating Trajectory Optimization of a Fed-Batch Fermenter"**,** *presented at CSChE National Meeting*, Halifax, Canada, 14-17 Oct., 2001.
59. Patwardhan, S.C. ; Shah S.L., **"**Predictive Control of Multivariable Systems subject to Unmeasured Disturbance Using Orthonormal Filters**",** *presented at CSChE National Meeting*, Halifax, Canada, 14-17 Oct., 2001.
60. Prakash, J., Shankar Narasimhan and S. C. Patwardhan " Integrating Model Based Fault Diagnosis with Model Predictive Control ", *presented at AIChE National Meeting*, Reno, U.S.A., 4-9 Nov. , 2001.
61. Patwardhan, S.C.; Shah S.L., " Simultaneous Estimation of Time Delays and Unmeasured Disturbance Models for Multivariable Systems Using Orthonormal Filters", *presented at AIChE National Meeting*, Reno, U.S.A., 4-9 Nov. , 2001.
62. Prakash, J., S. C. Patwardhan and Shankar Narasimhan " Fault Tolerant Control of Continuous Stirred Tank Reactor", *Proc. of International Conference on Communication, Control and Signal Processing*, Banglore, pp 117-121, July, 2000.

## Technical Reports

*1.* Kapadi, M ; Munawar, S. A.; Patwardhan, S. C. and K. P. Madhavan, "Advanced Planning and Scheduling Solutions for P3 (Paper, Pulp and Printing) Industries", *Technical Report submitted to Honeywell Technology Solutions Lab., Bangalore.* April, 2004.
*2.* Darji, A.; Patwardhan, S. C.; Gudi, R. D. and H. Pillay, "Performance of Evaluation of Wireless Sensor Networks for Control Applications". *Technical Report submitted to Honeywell Technology Solutions Lab., Bangalore.* July, 2006.
*3.* Badwe, A. ; Gudi, R. D. ; Patwardhan, S. C., "Model Maintenance in Advanced Process Control Schemes". *Technical Report submitted to Honeywell Technology Solutions Lab., Bangalore.* July, 2006.
*4.* Dasgupta, D. and Sachin C. Patwardhan, "Nonlinear Black-Box Model Identification For Predictive Control Of Fluidized Bed Reactor For Polyethylene Production" , *Technical Report submitted to Honeywell Technology Solutions Lab., Bangalore.* March, 2011.

**Patents filed**

The following patents have been jointly filed by Honeywell Technology Solutions Limited, Bangalore and I.I.T. Bombay based on consulting project carried out for HTSL, Bangalore
1. US Patent Title: Paper Manufacturing System and Method, Filing Date : 3rd August 2005, Patent Assignment Number: 11/196705.
2. Indian Patent Title: Paper Manufacturing System and Method, Filing Date : 5th May 2005., Serial Number : 1145/DEL/2005.

**Supervision of Ph. D. Thesis**

1. Prabir Kumar Saha, "Model Predictive Control of Chemical Processes using Nonlinear Laguerre Models", I.I.T. Madras, 1999.
2. J. Ptakash, "On-line Fault Tolerant Control Strategies for Linear Multivariable Systems", I.I.T. Madras , 2002. (Co-supervisor: Shankar Narasimhan)
3. K. Yamuna Rani, "Optimization and Control of Semi-Batch Processes Using Artificial Neural Networks",  I.I.T. Madras , 2002.
4. Seema Manuja, "Fault Tolerant Control of Complex Systems",  I.I.T. Madras, 2004. (Co-supervisor: Shankar Narasimhan)
5. M. Srinivasrao, "Nonlinear Predictive Control using Black-Box Nonlinear Observers", I.I.T. Bombay, 2006. (Co-supervisor: R. D. Gudi)
6. Ketan Detroja, "Fault Detection and Diagnosis in Large Scale Systems", I.I.T. Bombay, 2007. (Co-supervisor: R. D. Gudi)
7. Anjali Deshpande, "A Unified Framework for Online Fault Identification and Accommodation in Nonlinear Systems", I.I.T. Bombay, 2008.
8. Ravi Methekar, "Advanced Control of PEM Fuel Cell using Data Driven Models", I.I.T. Bombay,  2009. (Co-supervisor: R. D. Gudi).
9. Abhijit Badwe, "Model Maintenance For Linear Model Predictive Control", I.I.T. Bombay, July, 2010. (Co-supervisor: R. D. Gudi).
10. Muddu , M. "Predictive Control of High Order and Distributed Parameter Systems using Data Driven Models.", I.I.T. Bombay, July, 2010.
11. Shraddha Deshpande, "Computationally Efficient Model Based Control for Nonlinear and Fast Dynamic Systems", I.I.T. Bombay, Sept., 2010.
12. Vinay Bavdekar, "Identification of Discrete Stochastic Unmeasured Disturbance Models for Nonlinear Bayesian Grey Box Observers",  I.I.T. Bombay, Aug., 2011.
13. Jalesh Purohit, "Nonlinear Dynamic Analysis, State Estimation and Nonlinear Predictive Control of Reactive Distillation Systems", I.I.T. Bombay, *In progress*. (Co-supervisor: S. M. Mahajani)
14. Nishant Parikh, "Closed Loop Identification Strategies for Model Predictive Control", I.I.T. Bombay*, In Progress*. (Co-supervisor: R. D. Gudi)
15. Jayram, V., "Nonlinear Dynamic Analysis and Advanced Control of Reactive Distillation Systems", I.I.T. Bombay, *In progress*. (Co-supervisor: S. M. Mahajani).

**Keynote Address in Conferences**

- "Advanced Process Monitoring and Control: An Overview" in Aditya Birla Group Simulation Conference 2012, Mumbai, 5'th Dec., 2012.

- "Soft Sensing and Nonlinear State Estimation: A Review and New Results", International Conference on Process Automation, Control and Computing, (IEEE-PACC 2011), Coimbatore, India, 20-22 July, 2011.
- "Nonlinear Bayesian State Estimation: A Tutorial Review", International Conference on Trends in Industrial Automation (*TIMA 2011),* Chennai, 6-8 Jan., 2011.
- "Soft Sensing and State Estimation: Review and Recent Trends". *In IFAC Conference on Cost Effective Automation in Networked Product Development and Manufacturing,* Monterrey, Mexico, 3-5 Oct., 2007.
- "Nonlinear Model Predictive Control", In *National Conference on Identification, Control and Diagnosis*, Chennai, India, 15-16 Dec., 2005.

## Conference Area Chair / Associate Editor

- Served as "IPC Program Area Co-chair" (associate editor for conference proceedings) in *Advances in Model-based Control* area in DYnamics and Control of Process Systems (DYCOPS-2010), Leuven, Belgium, 5-7 July, 2010.

- Served as IPC member and associate editor for conference proceedings for IEEE Conference on Control Applications (CCA-2013), Hyredabad, India, Aug. 28-30, 2013.

## Organization of International Conference

- Organizing Secretary, International Symposium on Process Systems Engineering and Control (ISPSEC'03) held at I.I.T Bombay on 3-4, January, 2003.
- Co-chair, National Organizing Committee, Dynamics and Control of Process Systems (DYCOPS 2013), 18-20 Dec., 2013, IIT Bombay, Mumbai

## Sponsored Research Projects

1. Data Driven Model Based Predictive Control of Nuclear Steam Generator. (2008 – 11)
   *Sponsors:* Board of Research for Nuclear Sciences, India.
   *Collaborator:* Prof. Samtanu Bandyopadhyay, IIT Bombay
2. Nonlinear Model Identification For Predictive Control. (2009-10)
   *Sponsors:* Honeywell Technology Solutions Lab., Bangalore.
3. Model Maintenance in Advanced Process Control Schemes. (2004-06)
   *Sponsors:* Honeywell Technology Solutions Lab., Bangalore.
   *Collaborator:* Prof. R. D. Gudi, IIT Bombay
4. Development of Intelligent Wireless Control Networks. Phase I: Wireless Control of Distillation Column. (2004-06)
   *Sponsors:* Honeywell Technology Solutions Lab., Bangalore.
5. Advanced Planning and Scheduling for Paper, Pulp and Printing Industries. (2003-04)
   *Sponsors:* Honeywell Technology Solutions Lab., Bangalore.
   *Collaborator:* Prof. K. P. Madhavan, IIT Bombay
6. Development of on-line fault detection and diagnosis (FDD) methodologies in integrated scale complex plants. (2002-06)
   *Sponsors:* Board of Research for Nuclear Sciences, India.
   *Collaborator:* Prof. R. D. Gudi, IIT Bombay
7. Advanced Control and Intelligent Monitoring using a Networked Controller. (1999-2002)
   *Sponsors:* Dept. of Science and Technology, Govt. of India.

*Collaborator:* Prof. Shankar Narasimhan

8. Development of a Hardware Module using Multi-Chip Module (MCM) from TLON GmbH, Germany for Low Cost Automation. (1998-99)
   *Collaborators:* Prof. Ashok Jhunjhunwala, IIT Madras
   *Sponsors:* Infranet System Integrators, Chennai and TLON GmbH, Germany.

9. MERMAID – Model Based Environmental Resource Management Aid
   *Sponsors:* D.L.R., Germany and D.S.T., India. (96-99)
   *Collaborators:* Prof. Deepak Khemani, I.I.T Madras and  Prof. Peter Struss, Tech. University of Munich.

10. Model Predictive Control of Nonlinear Processes Using Laguerre Models.
    *Sponsors:*  All India Council for Technical Education,  New Delhi, 1995-1998.