Mo-Yuen Chow, Professor

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Research interest: Smart Gird/Micro Grid Energy Management and Control, Battery Modeling and Management, Mechatronics, Control, Artificial Intelligence and Learning

Google Number of Citations: 16482
H-index - Google Scholar: 60

I. Education

Cornell University, Ithaca, New York		
Electrical Engineering	Ph.D.	August 1987
Electrical Engineering	M. Eng.	August 1983
University of Wisconsin-Madison, Madison, Wisconsin		
Electrical and Computer Engineering	B.S.	June 1982

II. Professional Experience

Professor, Dept. of Elect. and Comp. Engineering, NCSU, July 1999 — present.
Distinguished Consultant, SAS Institute, August 16 – December 31, 2016.
Qiushi Chair Professor (求是讲座教授), Zhejiang University, China, January 1, 2015 – December 31, 2018.
Chang Jiang Chair Professor (长江讲座教授), Zhejiang University, China, March 1, 2010 – February 28, 2013.
Guest Professor (客座教授), Dept. of Electronics Department, Zhejiang University, January 2008 – present.
(Guest professor is an honorary position at Zhejiang University for overseas expert.)
Part-time Contractor at Army Research Office (ARO) managing the Systems and Control Program, Dec 2008 – Oct 2010.
Senior Research Scientist, U.S. Army Tank Automotive Research, Development and Engineering Center, May 13 – June 12, 2003.
Associate Professor, Dept. of Elect. and Comp. Engineering, NCSU, July 1993 – June 1999.
Visiting Scientist, Automation Distribution Division, ABB, Cary, NC, June – December 1995.
Assistant Professor, Dept. of Elect. and Comp. Engineering, NCSU, July 1991 – June 1993.
Visiting Assist. Professor, Dept. of Elect. and Comp. Engr., NCSU, August 1987 – June 1991.
Research Assistant, School of Electrical Engineering, Cornell University, 1984 – August 1987.
Teaching Assistant, School of Electrical Engineering, Cornell University, 1982 – 1984.

III. Scholarly and professional honors:

Awards

1. IEEE Industrial Electronics Society Eugene Mittelmann Career Award, June 2020.
2. IEEE IES Anthony J. Hornfeck Service Award, 2013.
3. IEEE Eastern North Carolina Outstanding Service Award, 2007
4. IEEE Region 3 Joseph M. Biedenbach Outstanding Engineering Educator Award, 2005.

5. IEEE Eastern North Carolina Outstanding Engineering Educator, 2004.
6. 2014 IEEE ICMC'2014 Best Paper Award: N. Otero, H. Rahimi-Eichi, J. J. Rodriguez-Andina, and M.-Y. Chow, "FPGA Implementation of an Observer for State of Charge Estimation in Lithium-Polymer Batteries," in IEEE International Conference on Mechatronics and Control, Jinzhou, China, July 3-5, 2014.
7. 2013 Best Paper Award for the IEEE Industrial Electronics Magazine: H. R. Eichi, U. Ojha, F. Baronti, and M.-Y. Chow, "Battery Management System: An Overview of Its Application in the Smart Grid and Electric Vehicles," Industrial Electronics Magazine, vol.7, no.2, pp.4-16, June 2013.
8. 2012 IEEE IES Student Best Paper Award, Wencong Su, Habiballah Rahimi-Eichi, Wente Zeng, Mo-Yuen Chow, "A Survey on The Electrification of Transportation in A Smart Grid Environment," IEEE Trans. on Industrial Informatics, vol.8, no.1, pp.1-10, Feb. 2012

Keynote Speakers

9. A keynote speaker of the IEEE 2ND International Conference on Industrial Electronics for Sustainable Energy Systems, "Resilient Networked Microgrids Energy Management System," Cagliari, Sardinia, September 1 – 3, 2020.
10. A keynote speaker of the 4th SJTU Future Information Technology International Forum for Young Scholars, "Resilient Cyberphysical System: Networked Microgrids Energy Management Systems," June 1, 2019.
11. A keynote speaker of "2015 IEEE International Conference on Industrial Technology", March 17-19, 2015, Seville, Spain, on the topic of " When e-Transportation Meets Distributed Renewable Energy Resources".
12. A keynote speaker of "3rd International Symposium on Resilient Control Systems" on August 10-12, 2010 on the topic of "Time-sensitive distributed control systems".

Recognition

13. IEEE IES Distinguish Lecturer, 2014 – present.
14. Qiushi Chair Professor (求是讲座教授), Zhejiang University, China, January 1, 2015 – December 31, 2018 - present.
15. Chang Jiang Chair Professor （长江讲座教授）, Zhejiang University, China, March 1, 2010 – Feb 28, 2013.
16. IEEE Fellow, 2007.
17. Senior fellow of Japan Society for the Promotion of Science in 2003.

IV. Appointments or Election to Study Sections and Editorial Boards

1) 2014 – 2018, Co-Editor-in-Chief of IEEE Transactions on Industrial Informatics
2) 2016 – present, International Editorial Advisory Board of IEEJ Journal of Industry Applications.
3) 2015 – present, Advisory Board, Journal of Modern Power Systems and Clean Energy (MPCE) (**http://www.mpce.info**). (EiC - Yusheng XUE)
4) 2015 Guest Editor (Wei Qiao, Pinjia Zhang, M.-Y. Chow) on IEEE Transactions on Industrial Electronics Special Section on: Condition Monitoring, Diagnosis, Prognosis, and Health Management for Wind Turbine Generators.
5) 2015 Guest Editor (Jiming Chen, Ling Shi, M.-Y. Chow) on IEEE Transactions on Industrial Informatics Special Section on Secure Detection, Estimation, and Control in Cyber-Physical Systems.
6) 2014 Guest Editor (Huijun Gao, M.-Y. Chow, Jianbin Qiu) on IEEE Transactions on Industrial Electronics Special Section on Networked Control and Industrial Applications.
7) 2014 Editorial board of IEEE Trans Energy Conversion- Special issue on Advanced distributed control of energy conversion devices and systems (GE: Dr. Ali Davoudi).

8) 2010 – 2012, Editor-in-Chief of IEEE Transactions on Industrial Electronics
9) 2009, Co-Editor-in-Chief of IEEE Transactions on Industrial Electronics.
10) 2008 May – present, Editorial Board of International Journal of Computational Intelligence in Control (IJCIC).
11) 2008 – 2009, Associate Editor of IEEE Transactions on Mechatronics
12) 2008 Guest Editor (with Drs. Xiao-Zhi Gao, David Pelta, and Jon Timmis) of the Special Issue on Artificial Immune Systems: Theory and Applications, Journal of Neural Computing and Applications. http://www.springerlink.com/content/d00254k7757746m3/.
13) 2008 Guest Editor (with Stefano Chiaverini and Christopher Kitts) of IEEE/ASME Transactions on Mechatronics Focused Section Mechatronics in Multi Robot Systems.
14) 2007 – 2008, Associate Editor of IEEE Transactions on Industrial Informatics
15) 1992 – 2008, Associate Editor of IEEE Transactions on Industrial Electronics
16) 2004, Guest Editor of IEEE Transactions on Industrial Electronics Special Issue on Distributed Network-Based Control Systems and Applications
17) 1999, IEEE Industrial Electronics Society Newsletter Editor
18) 1999, Guest Editor of IEEE Transactions on Industrial Electronics Special Issue on Motor Fault Detection and Diagnosis
19) 1994, Guest Editor of IEEE Transactions on Industrial Electronics Special Issue on Application of Intelligent Systems to Industrial Electronics

V. Conferences (selected)

1) 2022 IEEE ICIT, General Co-Chair, Shanghai, China, March 28-31, 2022.
2) 2020 IEEE INDIN, General Co-Chair, Guangzhou, China, July 12-15, 2020.
3) 2020 IEEE IESES, General Co-Chair, Cagliari, Sardinia, Italy, April 20-22.
4) 2019 IEEE IECON, General Co-Chair, Lisbon, Portugal, October 14-17, 2019.
5) 2019 IEEE ISIE, General Co-Chair, Vancouver, Canada, June 8-10, 2019.
6) 2018 IEEE IECON, General Co-Chair, Washington, DC, USA, October 21-23, 2018.
7) 2018 IEEE AMC, Program Co-Chair, Tokyo, Japan, March 9-11, 2018.
8) 2018 IEEE ICIT, General Co-Chair, Lyon, France, February 20-22, 2018
9) 2018 IEEE IESES, General Co-Chair, Hamilton, Waikato, New Zealand, Jan 31 - Feb 2, 2018.
10) 2015, IEEE Industrial Electronics Conference Technical Co-Chair, Yokohoma, Japan, Nov, 2013.
11) 2013, IEEE Industrial Electronics Conference Technical Co-Chair, Vienna, Austria, Nov, 2013.
12) 2012 IEEE International Symposium on Industrial Electronics General co-Chair, Hangzhou, Zhejiang, China
13) 2010 IEEE Industrial Electronics Conference General co-Chair, November, Glendale, AZ,
14) 2005, IEEE Industrial Electronics Conference General Chair, Raleigh, NC, Nov. 6-10, 2005
15) 2003 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM2003) Technical Program Co-Chair, International Conference Center, Port Island, Kobe, Japan, July 20-24, 2003.

VI. Teaching Highlights

A. Student Mentoring:

1) Number of current PhD Students: 3
2) Number of current MS Student: 1
3) Number of PhD Students Graduated: 20
4) Number of MS Thesis Students Graduated: 15
5) Number of MS Non-Thesis Students Advised: 27

B. Courses Taught:

1) ECE212 Circuit Analyses
2) ECE410 Data and Computer Communications
3) ECE435 Elements of Control
4) ECE456 Mechatronics
5) ECE492J Fuzzy and Adaptive (Neural) Systems
6) ECE516 System Control Engineering
7) ECE556 Mechatronics
8) ECE591J Fuzzy and Adaptive (Neural) Systems
9) ECE691C Fast Prototyping System Design and Implementation
10) ECE692C Application of Neural Network and Fuzzy Logic Technology for Motor Fault Detection
11) ECE726 Advanced Feedback Control
12) ECE792C Fuzzy and Adaptive (Neural) Systems
13) ECE756 Advanced Mechatronics

VII. Publications

A. Book and Book Chapters (published or accepted for publications)

[1] M.-Y. Chow, Methodologies of Using Artificial Neural Network and Fuzzy Logic Technologies for Motor Incipient Fault Detection: World Scientific Publishing Co. Pte. Ltd., 1998.

[2] H. Rahimi-Eichi and M.-Y. Chow, "Batteries:. The World Scientific Handbook of Energy (p. 700), G. M. Crawley, Ed., ed, World Scientific Pub Co Inc. and Imperial College Press, 2012. (invited)

[3] Z. Zhang and M.-Y. Chow, "The Influence of Time Delays on Decentralized Economic Dispatch by Using Incremental Cost Consensus Algorithm," in Control and Optimization Theory for Electric Smart Grids, M. D. I. a. A. Chakrabortty, Ed.: Springer 2011. (invited)

[4] M.-Y. Chow, "Fuzzy Logic Based Control," accepted for publication in IEEE Industrial Electronics Handbook, May 26, 2009. (invited)

[5] J. M. Fuertes, M.-Y. Chow, R. Villà, R. Gupta, and J. Ayza, "Network Based Control," in accepted for publication in IEEE Industrial Electronics Handbook, May 26, 2009. (invited)

[6] L. Xu and M.-Y. Chow, "Power Distribution System Fault Diagnosis Using Hybrid Algorithm of Fuzzy Classification and Artificial Immune Systems," in Soft Computing Applications in Industry, B. Prasad, Ed. Springer-Verlag Berlin Heidelberg, 2008, pp. 357–372. (invited)

[7] R. A. Gupta and M.-Y. Chow, "Overview of Time Sensitive Network Control Systems," in Networked Control Systems: Theory and Applications, Fei-Yue Wang and D. Liu, Eds.: Springer-Verlag, June 17, 2008, pp. 1-23. (invited)

[8] M.-Y. Chow, Neural Control, CRC Electrical Engineering Handbook, January, 2000. (invited)

[9] M.-Y. Chow, B. Li, and G. Goddu, "Intelligent Motor Fault Detection," in Intelligent Techniques in Industry, L. C. Jain, Ed.: CRC Press, 1998. (invited)

[10] M.-Y. Chow, "Fuzzy Logic Based Control," in The Industrial Electronics Handbook, D. Irwin, Ed., 1997, pp. 564-571. (invited)

[11] M.-Y. Chow, "Fuzzy Systems," in The Industrial Electronics Handbook, D. Irwin, Ed.: CRC Press, 1997, pp. 1096-1102. (invited)

[12] M.-Y. Chow, Y.-S. Lee, and H. J. Trussell, "Motor Incipient Fault Detection Using Artificial Neural Network and Fuzzy Logic Technologies," in Computer Aided Maintenance, Methodology and Practices, J. Lee, Ed. United Kingdom: Chapman Hall, 1996. (invited)

B. Tutorials

[1] Federico Baronti, Mo-Yuen Chow, Martin Wenger, "New Trends in Battery Management System (BMS) Design," IEEE IECON15, Yokohama, Japan, Nov 9, 2015.

[2] Mo-Yuen Chow, Federico Baronti, "Advances in battery system design for electrified vehicles," IEEE IECON14 Tutorial, Dallas, TX, Oct 28-Nov 1, 2014.
[3] Simona Onori, Federico Baronti, Mo-Yuen Chow, Robyn Jackey, Kevin Rzemien, Developing Battery Management Systems using Model-Based Design, American Control Conference Half-Day Workshop, June 3, 2014.
[4] Federico Baronti, Mo-Yuen Chow, "Tutorial on Going electric needs advanced energy storage management", 2013 IEEE International Symposium on Industrial Electronics (ISIE), 28-31 May 2013.
[5] Federico Baronti, Mo-Yuen Chow, "Tutorial on Advanced Management of Lithium Batteries and innovative applications of supercapacitors," 2012 IEEE International Symposium on Industrial Electronics (ISIE), 28-31 May 2012.
[6] M.-Y. Chow, "Tutorial on Controlling the Smart Grid: from Challenges to Opportunities," IECON 2011 - 37th Annual Conference of the IEEE Industrial Electronics Society, Melbourne, Australia, Nov 7-10, 2011.
[7] M.-Y. Chow, "Distributed Network-Control Systems and Applications," The 35th Annual Conference of the IEEE Industrial Electronics Society (IECon'08), Nov. 3-5, 2009, Porto, Portugal.
[8] Bartosz Wojszczyk, Johan Enslin, Subbaiah V Pasupulati, Mo-Yuen Chow, "Renewable Energy Sources: Massive Integration and Its Impact on Power System Design, Operation and Performance", Renewable Energy World Conference & Expo, March 10-12, 2009, Las Vegas, Nevada.
[9] M.-Y. Chow, "Distributed Network-Control Systems and Applications," The 34th Annual Conference of the IEEE Industrial Electronics Society (IECon'08), Nov. 10-13, 2008, Orlando, FL.
[10] M.-Y. Chow, "Distributed Network-Control Systems," IEEE ICIT08, Apr. 21-23, 2008, Chengdu, China.
[11] M.-Y. Chow, "Distributed Network-Control Systems," The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECon'07), Nov. 5-7, 2007, Taipei, Taiwan.
[12] M.-Y. Chow, "Network-Based Control and Application," 2007 IEEE International Symposium on Industrial Electronics (ISIE07), Vigo, Spain, 4-7 June, 2007.
[13] M.-Y. Chow, "Network-Based Control," 2005 IEEE/ASME International Conference on Advanced Intelligent Mechatronics, Monterey, CA, 24-28 July, 2005.
[14] M.-Y. Chow, "Network-Based Control," The 30th Annual Conference of the IEEE Industrial Electronics Society (IECon'04), Nov. 2-6, 2004, Busan, Korea.
[15] M.-Y. Chow, "Electric Motor Fault Detection and Diagnosis," International Conference on Electrical Machines and Systems 2004 (ICEMS 2004), Nov. 1-3, 2004, Jeju Island, Korea.
[16] M.-Y. Chow, "Methodologies in Time Sensitive Network-Based Control Systems," 2003 IEEE/ASME International Conference on Advanced Intelligent Mechatronics, Port Island, Kobe, Japan, July 20-24, 2003.
[17] M.-Y. Chow, Y. Tipsuwan, "Real Time Network-Based Control System," IEEE IECon 2002 Tutorial, Sevilla, Spain, November 5, 2002.
[18] M.-Y. Chow, Y. Tipsuwan, "Network-Based Control Systems: A Tutorial," Proceedings of IEEE IECon 2001 Tutorial, November 28 – December 2, Denver, CO, pp. 1593 -1602.
[19] M.-Y. Chow, "Neural-Fuzzy system for Motor Incipient Fault Detection and Diagnosis," IEEE IECon 2000 Tutorial, October 23-24, 2000, Nagoya, Japan.
[20] M.-Y. Chow, "Optimization Techniques", Fuzzy Set Tutorial, IEEE Winter Power Meeting, January 2000.
[21] M.-Y. Chow, "Optimization Techniques", Fuzzy Set tutorial, IEEE PICA, May 1997.

C. Journal Publications (Published or Accepted for Publication)

[1] Z. Cheng, and M.-Y. Chow, “Resilient Collaborative Distributed Energy Management System Framework for Cyber-physical DC Microgrids,” IEEE Transaction on Smart Grid, accepted for publication June 2020, in press.
[2] H. Sun, L.-Yang, M.-Y. Chow, J. Zhou, “A Multiagent System Based Optimal Load Restoration Strategy in Distribution Systems,” International Journal of Electrical Power and Energy Systems, accepted for publication on February, 2020, in press.
[3] B. Zhang, P. Zhang, T. Vu, M.-Y. Chow, “Guest Editorial: Special Section on Resilience, Reliability, and Security in Cyber–Physical Systems,” IEEE Transactions on Industrial Informatics, vol. 16, no. 7, pp. 4865-4867.
[4] J. Zhou, Y. Xu, H. Sun, L. Wang, M.-Y. Chow, “Distributed Event-Triggered H∞ Consensus Based Current Sharing Control of DC Microgrids Considering Uncertainties,” IEEE Transactions on Industrial Informatics, accepted on Dec 20, 2019.
[5] J. Zhou, Y. Xu, H. Sun, Y. Li, M.-Y. Chow, “Distributed power management for networked ac–dc microgrids with unbalanced microgrids,” IEEE Transactions on Industrial Informatics, vol. 16, no. 3, pp. 1655-1667, June 2019.
[6] I. Khan, Y. Xu, S. Kar, M.-y. Chow, and V. Bhattacharjee, "Compressive Sensing and Morphology Singular Entropy-Based Real-Time Secondary Voltage Control of Multiarea Power Systems," IEEE Transactions on Industrial Informatics, vol. 15, pp. 3796 - 3807, July 2019.
[7] Z. Yi, Y. Xu, J. Hu, M.-Y. Chow, and H. Sun, "Distributed Neurodynamic-based Approach for Economic Dispatch in an Integrated Energy System," IEEE Transactions on Industrial Informatics (Early Access), March 14 2019.
[8] J. Duan and M.-Y. Chow, "Robust Consensus-based Distributed Energy Management Algorithm With Packet Losses Tolerance," IEEE Transactions on Smart Grid, March 17 accepted for publications 2019.
[9] L. An, J. Duan, M.-Y. Chow, and A. Duel-Hallen, "A Distributed and Resilient Bargaining Game for Weather-Predictive Microgrid Energy Cooperation," IEEE Transactions on Industrial Informatics, Accepted for Publication on March 15, 2019 2019.
[10] J. Duan, W. Zeng, and M.-Y. Chow, "Resilient Distributed DC Optimal Power Flow Against Data Integrity Attack," IEEE Transactions on Smart Grid vol. 9, pp. 3543-3552, July 2018.
[11] F. Baronti, S. Vazquez, and M.-Y. Chow, "Modeling, Control, and Integration of Energy Storage Systems in E-Transportation and Smart Grid," IEEE Transactions on Industrial Electronics, vol. 65, pp. 6548 - 6551, Aug 2018.
[12] J. Hu, J. Duan, H. Ma and M. Y. Chow, "Distributed Adaptive Droop Control for Optimal Power Dispatch in DC Microgrid," in IEEE Transactions on Industrial Electronics, vol. 65, no. 1, pp. 778-789, Jan. 2018.
[13] J. Duan; W. Zeng; M. -Y. Chow, "Resilient Distributed DC Optimal Power Flow Against Data Integrity Attack," accepted for publication in IEEE Transactions on Smart Grid , Nov 2016.
[14] Y. Zhang, N. Rahbari-Asr, J. Duan and M. -Y. Chow, "Day-Ahead Smart Grid Cooperative Distributed Energy Scheduling With Renewable and Storage Integration," IEEE Transactions on Sustainable Energy, vol. 7, no. 4, pp. 1739-1748, Oct. 2016.
[15] F. Baronti, M.-Y. Chow, C. Ma, H. Rahimi-Eichi, and R. Saletti, " E-Transportation: the Role of Embedded Systems in Electric Energy Transfer from Grid to Vehicle," special issue of EURASIP Journal of Embedded Systems, accpeted for publication on April 23 2016.
[16] H. Yin, C. Zhao, M. Li, C. Ma, and M.-Y. Chow, "A Game Theory Approach to Energy Management of An Engine-Generator/Battery/Ultracapacitor Hybrid Energy System," IEEE Transaction on Industrial Electronics, Accepted on 2016-01-26.
[17] J. Qiu, H. Gao, and M.-Y. Chow, "Networked Control and Industrial Applications," IEEE Transactions on Industrial Electronics, vol. 63, pp. 1203-1206, February 2016.

[18] N. Rahbari-Asr, Y. Zhang, and M.-Y. Chow, “Consensus-based distributed scheduling for cooperative operation of distributed energy resources and storage devices in smart grids”, IET Generation, Transmission & Distribution, 2016, DOI: 10.1049/iet-gtd.2015.0159
[19] Y. Zhang, N. R. Asr, and M.-Y. Chow, "A Robust Distributed System Incremental Cost Estimation Algorithm for Smart Grid Economic Dispatch with Communications Information Losses," Journal of Network and Computer Applications, vol. 59, pp. 315-324, Jan 2016.
[20] R. Deng, Z. Yang, M.-Y. Chow, J. Chen, “A survey on demand response in smart grids: Mathematical models and approaches,” IEEE Transactions on Industrial Informatics, vol. 11, no. 3, pp. 570-582, 2015.
[21] R. Deng, Z. Yang, F. Hou, M.-Y. Chow, J. Chen, “Distributed real-time demand response in multiseller–multibuyer smart distribution grid,” IEEE Transactions on Power Systems, vol. 30, no. 5, p. 2364-2374, 2015.
[22] M. A. Salmani, N. Rahbari-Asr, C. S. Edrington, and M.-Y. Chow, "Online and Offline Stability Analysis Methods for the Power Electronic-based Components in Design and Operational Stages " IEEE Transactions on Power Electronics, vol. accepted for publication on May 15, pp. 1-14, 2015.
[23] Angel Cuenca; Unnati Ojha; Julián Salt; M.-Y. Chow, “A non-uniform multi-rate control strategy for a Markov chain-driven Networked Control System,” Information Sciences, pp. 31-47, DOI information: 10.1016/j.ins.2015.05.035, May 2015.
[24] R. Deng, Z. Yang, J. Chen, M.-Y. Chow, “Load scheduling with price uncertainty and temporally-coupled constraints in smart grids,” IEEE Transactions on Power Systems, vol. 29, no. 6, pp. 2823-2834, 2014.
[25] N. Rahbari-Asr, U. Ojha, Z. Zhang, and M.-Y. Chow, "Incremental Welfare Consensus Algorithm for Cooperative Distributed Generation/Demand Response in Smart Grid," IEEE Transactions on Smart Grid, vol.5, no.6, pp.2836-2845, Nov. 2014.
[26] W. Zeng and M.-Y. Chow, "A Reputation-based Secure Distributed Control Methodology in D-NCS," IEEE Transactions on Industrial Electronics, vol.61, no.11, pp.6294-6303, Nov. 2014.
[27] W. Zeng and M.-Y. Chow, "Resilient Distributed Control in the presence of Misbehaving Agents in Networked Control Systems," IEEE Transactions on Cybernetics B, vol. 44, No. 11, Nov 2014.
[28] N. Rahbari-Asr and M.-Y. Chow, "Cooperative Distributed Demand Management for Community Charging of PHEV/PEVs Based on KKT Conditions and Consensus Networks," IEEE Transactions on Industrial Informatics, vol. 10, No. 3, August, 2014.
[29] R. Deng, Z. Yang, J. Chen, N. R. Asr, and M.-Y. Chow, "Residential Energy Consumption Scheduling: A Coupled-Constraint Game Approach," IEEE Transactions on Smart Grid, vol. 5, pp. 1340-1350, May 2014.
[30] H. Rahimi-Eichi, F. Baronti, and M.-Y. Chow, "Online Adaptive Parameters Identification and SOC Co-Estimation for Li-Polymer Battery Cells," IEEE Transaction on Industrial Electronics, vol. 61, pp. 2053-2061, 2014.
[31] J. Rodríguez-Araújo, J. J. Rodríguez-Andina, J. Fariña, and M.-Y. Chow, "Field-Programmable System-on-Chip for Localization of UGVs in an Indoor iSpace," IEEE Transactions on Industrial Informatics, vol. 10, no. 2, May 2014, pp.1033-1043, DOI: 10.1109/TII.2013.2294112.
[32] W. Zeng and M.-Y. Chow, "Modeling and Optimizing the Performance-security Trade-off in D-NCS using the Coevolutionary Paradigm," IEEE Transactions on Industrial Informatics, Special Section on Advances in Theories and Industrial Applications of Networked Control Systems, vol.9, no.1, pp.394-402, 2013.
[33] Z. Zhang and M.-Y. Chow, "The Convergence Analysis of Incremental Cost Consensus Algorithm under Different Communication Network Topologies in a Smart Grid," IEEE Transactions on Power Systems, vol. 27, no. 4, pp. 1761 - 1768, Nov, 2012.

[34] W. Zeng and M.-Y. Chow, "Optimal Trade-off between Performance and Security in Networked Control Systems based on Coevolutionary Algorithms," IEEE Transactions on Industrial Electronics, vol. 59, pp. 3016 - 3025, 2012.
[35] W. Su and M.-Y. Chow, "Computational Intelligence-based Energy Management for a Large-scale PHEV/PEV Enabled Municipal Parking Deck," Applied Energy, vol. 96, pp. 171-182, August 2012.
[36] W. Su, H. Eichi, W. Zeng, and M.-Y. Chow, "A Survey on the Electrification of Transportation in a Smart Grid Environment," IEEE Transactions on Industrial Informatics, vol. 8, no. 1, pp. 1-10, 2012.
[37] W. Su and M.-Y. Chow, "Performance Evaluation of An EDA-based Large-scale Plug-in Hybrid Electric Vehicle Charging Algorithm," IEEE Transactions on Smart Grid, Special Issue on Transportation Electrification and Vehicle-to-Grid Applications, vol. 3, no.1, pp. 308-315, March 2012.
[38] H. Li, Z. Sun, M.-Y. Chow, and F. Sun, "Gain Scheduling-Based State Feedback Integral Control for Networked Control Systems," IEEE Transactions on Industrial Electronics, vol. 58, no. 6, June 2011.
[39] Y. Cai and M.-Y. Chow, "Cause-Effect Modeling and Spatial-Temporal Simulation of Power Distribution Fault Events," IEEE Transactions on Power Systems, vol. 26, no. 2, pp. 794 - 801, May 2011.
[40] R. A. Gupta and M.-Y. Chow, "Networked Control Systems: Overview and Research Trends," IEEE Transactions on Industrial Electronics, vol. 57, no. 7, pp. 2527 - 2535 July 2010.
[41] Y. Cai, M.-Y. Chow, W. Lu, and L. Li, "Statistical Feature Selection from Massive Data in Distribution Fault Diagnosis," IEEE Trans. Power System, vol. 25, pp. 642-648, 2010.
[42] R. A. Gupta, A. Masoud, and M.-Y. Chow, "A Delay-tolerant, Potential field-based, Network Implementation of an Integrated Navigation System," IEEE Transactions on Industrial Electronics, vol. 57, no. 2, Feb 2010, pp. 769-783.
[43] X. Z. Gao, S. J. Ovaska, X. Wang, and M.-Y. Chow, "Multi-level optimization of negative selection algorithm detectors with application in motor fault detection," Intelligent Automation and Soft Computing, vol. 16, 2010, pp. 353-375.
[44] H. Li, M.-Y. Chow, and Z. Sun, "State Feedback Stabilization of Networked Control Systems," IET Control Theory & Applications, vol.3, no.7, July 2009, pp. 929-940.
[45] X.-Z. Gao, M.-Y. Chow, D. Pelta, and J. Timmis, "Editorial: Theory and Applications of Artificial Immune Systems, "Neural Computing & Applications, accepted for publication, May 2009.
[46] H. Li, M.-Y. Chow, and Z. Sun, "EDA-Based Speed Control of a Networked DC Motor System With Time Delays and Packet Losses," IEEE Transactions on Industrial Electronics, vol. 56, pp. 1727-1735, May 2009.
[47] X.-Z. Gao, S. J. Ovaska, X. Wang, and M.-Y. Chow, "Clonal Optimization-based Negative Selection Algorithm with Applications in Motor Fault Detection," Neural Computing and Applications, accepted for publication April 22 2009.
[48] M.-Y. Chow, S. Chiaverini, and C. Kitts, "Guest Editorial on Focused Section on Mechatronics in Multi Robot Systems," IEEE Transactions on Mechatronics, vol. 14, pp. 133-140, April 2009, pp. 133-140.
[49] H. Li, M.-Y. Chow, and Z. Sun, "Optimal Stabilizing Gain Selection for Networked Control Systems With Time Delays and Packet Losses," IEEE Transactions on Control Systems Technology, vol. 17, no. 5, pp. 1154-1162, 2009.
[50] A. Ayhan, H. J. Trussell, M.-Y. Chow, and M.-H. Song, "On the use of a lower sampling rate for broken rotor bar detection with DTFT and AR based spectrum methods," IEEE Transaction on Industrial Electronics, vol 55, no. 3, March 2008, pp. 1421-1434.

[51] Hongbo Li, Zengqi Sun, M.-Y. Chow, and Huaping Liu, “Output Feedback Control for a Class of Networked Control Systems,” accepted for publication in Asian Journal of Control, October, 2007.
[52] X.-Z. Gao, S. J. Ovaska, X. Wang, and M.-Y. Chow, "A neural networks-based negative selection algorithm in fault diagnosis," Neural Computing and Applications, vol. 17, no. 1, pp. 91-98, November 2007.
[53] L. Xu, M.-Y. Chow, and L. S. Taylor, "Power Distribution Fault Cause Identification with Imbalanced Data Using the Data Mining Based Fuzzy Classification E-Algorithm," IEEE Transaction on Power Systems, vol. 22, no. 1, Feb. 2007, pp. 164-171.
[54] L. Xu, M.-Y. Chow, and L. S. Taylor, "Power Distribution Fault Cause Identification with Imbalanced Data Using Artificial Immune Recognition System (AIRS) Algorithm," IEEE Transaction on Power Systems, vol. 22, no. 1, Feb. 2007, pp. 198-204.
[55] B. Ayhan, M.-Y. Chow, and M.-H. Song, "Multiple Discriminant Analysis and Neural-Network-Based Monolith and Partition Fault-Detection Schemes for Broken Rotor Bar in Induction Motors," IEEE Transactions on Industrial Electronics, vol. 53, no. 4, pp. 1298-1308, 2006.
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IX. Sponsored and non-sponsored projects

[1] Title: "High temperature embedded/integrated sensors (HiTEIS) for remote monitoring of reactor and fuel cycle systems," $999,688.00 (Xiaoning Jiang (PI), Mohamed Bourham, Mo-Yuen Chow, Leigh Winfrey (University of Florida)), my share: $200,000.00, funded by DOE Nuclear Engineering, 10/1/2017-9/30/2021.

The objective of this project is to develop embedded/integrated high temperature (>600oC), radiation resistant piezoelectric sensors for remote monitoring of NPP reactor and fuel cycle systems.

[2] Title: "Collaborative Distributed Energy Management System (CoDEMS) for Optimal Energy Management in Microgrids," $42,540, 8/16/20 – 2/15/21.

The core of CoDEMS is a rolling-horizon optimization that set both the day-ahead optimal schedule and 5-min re-dispatch commands. By leveraging the consensus-based distributed optimization technique, the global optimization can be solved by individual on-site DER (distributed energy resources) controllers collectively. The proposed distributed control framework delivers not only the same control functions as the centralized framework but provides greater scalability, reliability, and resiliency.

[3] Title: "Prototyping a Smart Battery Gauge Technology for Stationary Energy Storage of Renewable Energy Resources", funded by NSF-PFI:AIR, (NSF 1500208, FAS) $321,851, 5/16/15 – 9/30/20.

The Smart Battery Gauge technology aims to improve the reliability and safety of energy storage systems. As compared to the existing battery monitoring methods, the reliably accurate estimation date generated by this technology will provide systems management and operations with the advantages of improved energy storage system efficiency, reliability, cost-effectiveness, longer lifespan, and reduced capital and operation/maintenance costs.

[4] Title: "Breakthrough: Collaborative: Secure Algorithms for Cyber-Physical Systems", funded by NSF, (NSF 1505633, FAS 570294), $166,654, 7/15/15 – 6/30/20.

To formulate a novel methodology for creating secure algorithms in cyber-physical systems and to develop metrics for evaluating the security of composed systems.

[5] Title: "Smart Battery Gauge for Continuous Battery Assessment", funded by Caper (Center for Advanced Power Engineering Research) and Duke Energy Company, $90,000.00, 5/16/18 – 02/28/20.

To validate the value proposition of the Smart Battery Gauge (SBG) by demonstrating its ability to accurately estimate the State of Charge (SOC), State of Health (SOH) and the Remaining Useful Life (RUL) in real-time and while the energy storage device is in use on an active Duke Energy grid node.

[6] Title: "Real-Time Remaining Useful Life Assessment for Batteries using the SBG (Smart Battery Gauge) at Butler Farm", funded by NCEMC, $23,437.00, 5/16/19 – 10/15/19.

To develop an on-line Real-Time Remaining Useful Life Assessment on an active NCEMC energy storage system.

[7] Title: "Smart Battery Gauge for Continuous Battery Health Assessment at Butler Farm", funded by NCEMC, $30,884.00, 8/16/18 – 2/15/19.

To develop an on-line Smart Battery Gauge (SBG) Health Assessment on an active NCEMC energy storage system.

[8] Title: "Smart Battery Gauge for Continuous Battery Assessment at Butler Farm", funded by NCEMC, $30,452.00, 2/1/18 – 7/30/18.

To develop an on-line Smart Battery Gauge (SBG) by demonstrating its ability to accurately estimate the State of Charge (SOC), State of Health (SOH) and the Remaining Useful Life (RUL) in real-time and while the energy storage device is in use on an active NCEMC energy storage system.

[9] Title: "Implementation of Collaborative Distributed Energy Management and Reputation-based Resilient distributed Control for FREEDM System", funded by FREEDM, $50,000.00, 9/1/17 – 8/31/18.

Implemented Secured CoDES algorithm in DGI platform for validation and demonstration in GEH and HIL testbeds.

[10] Title: "Online Adaptive Parameter Identification and SoC Co-estimation for Lithium-ion Battery", funded by Huawei Co., $223,133.00, 12/1/16 – 10/30/18.

The target of this project is to develop an online parameter identification algorithm, identify the parameter of battery model and improve the model accuracy of aging batteries, thus to eliminate the impact to the status estimation accuracy caused by aging-state.

[11] Title: "Cooperative Distributed Home Energy Management Systems", funded by Total Inc., $351,033.00, 9/1/15 – 2/28/17.

The goal of this task is to develop a cooperative distributed Home Energy Management System (HEMS) for 1) a single house, and 2) aggregated houses. In this cooperative distributed HEMS, energy sources and loads can coordinate and cooperate with each other to maximize the user comfort, meet the power constraints (e.g., avoid over-loading), optimize the power flows, decrease the system cost and the electricity bill in a single house and among aggregated houses. It also includes smart battery charging/discharging strategies to optimize the integration of the energy storage system. The project consists of design, development and demonstration phases.

[12] Title: "Big Data based Adaptive Range Estimation Project", funded by Samsung Electronics Inc., $99,000, 10/1/15 – 9/30/16.

Design and develop an adaptive range estimation algorithm that considers the real time factors extracted from big-data analysis and updates the range estimation results during the trip.

[13] Title: "Cooperative Distributed Energy Management," $90,000.00, funded by NSF FREEDM Energy Research Center (NSF EEC-0812121, FAS 529670), 9/1/2015-8/31/2016.
Research and develop Resilient Cooperative Distributed Energy Scheduling (CoDES) algorithm for FREEDM System energy management.

[14] Title: "Breakthrough: Collaborative: Secure Algorithms for Cyber-Physical Systems", funded by NSF, (NSF 1505633, FAS 570294), $166,654, 7/15/15 – 9/30/18.
To formulate a novel methodology for creating secure algorithms in cyber-physical systems and to develop metrics for evaluating the security of composed systems.

[15] Title: "Prototyping a Smart Battery Gauge Technology for Stationary Energy Storage of Renewable Energy Resources", funded by NSF-PFI:AIR, (NSF 1500208, FAS) $242,188.00, 5/16/15 – 6/30/18.
The Smart Battery Gauge technology aims to improve the reliability and safety of energy storage systems. As compared to the existing battery monitoring methods, the reliably accurate estimation date generated by this technology will provide systems management and operations with the advantages of improved energy storage system efficiency, reliability, cost-effectiveness, longer lifespan, and reduced capital and operation/maintenance costs.

[16] Title: "Distributed Grid Intelligence/Reliable Secured Communications," $60,000.00, funded by NSF FREEDM Energy Research Center (NSF EEC-0812121, 529670), 9/1/2014-8/31/2015.
DGI/RSC is FREEDM's "Operating System" providing resource management services to the IEM, IFM, and IPM and interfacing with SST. The composition of these diverse systems presents significant security challenges and vulnerabilities spanning beyond those of traditional network and cyber security. This project produces a set of security policies for FREEDM, a set of security rules to be enforced by "Security Mechanisms" or software/hardware/network protection code processes, and hardware features.

[17] Title: "Green Energy Hub – (Intelligent Energy Management – Chow)," $ 210,000, funded by NSF FREEDM Energy Research Center (NSF EEC-0812121, 559825), 9/1/2014-8/31/2015. PI: David Lubkeman, Co-PIs: Mo-Yuen Chow (share: $60,000.00)
The objective of this task is to demonstrate the effectiveness and efficiency of the FREEDM IEM functionality in Green Energy Hub (GEH) testbed. One FREEDM SST and two simulated SSTs on single board computers will be used in this task. Each of them will have multiple controllable devices connected to it. Instead of using centralized SCADA system, selected distributed IEM algorithms (e.g., Incremental Cost Consensus Algorithm) will be implemented in embedded distributed controllers on each individual controllable device to send dispatch commands to each distributed generation unit.

[18] ERC for Future Renewable Electric Energy Distribution and Management (FREEDM) Systems, Iqbal Husain, Ewan Gareth David Pritchard, Edward A. Baker, Srdjan Miodrag Lukic, Wenye Wang, Mesut E. Baran, Mo-Yuen Chow, Penny Shumaker Jeffrey, Alex Q. Huang, Mark A. Johnson, National Science Foundation (NSF) $22,910,403.00, 09/01/08 - 08/31/16.
The FREEDM system vision is a vision for an Energy Internet. The Energy Internet requires that society move away from, or at least supplement, the traditional centralized generation, distribution, and consumption business model to one where every user can actively participate in the energy market. In this Energy Internet market, individual residential customers or a group of entities, including the utility company, organized as an Energy Cell can be either the electricity consumer or the electricity supplier. The FREEDM System, under the development by the FREEDM System ERC, is such a revolutionary and resilient power grid suitable for this purpose.

[19] Title: "Big Data Framework for Battery SOF and SOH Estimation," $99,000.00, funded by Samsung Elect Co. Ltd – Korea (557922), 02/01/2014 - 01/31/2015.
This project will develop an effective and robust framework to discover and analyze the factors that are important in SOF and SOH estimation of the batteries with:
a) Qualitative demonstration of the relationships between the SOF/SOH estimation parameters and the available data,
b) Quantitative evaluation of the relativeness, importance and required resolution of different unstructured data types to refine the estimation performance.

[20] Title: "Vehicle to grid/vehicle to home communications," $100,000.00, funded by Ford Motor Company (677847), 1/1/2014 – 12/31/2015.

[21] Title: "Verification of FREEDM System Control Robustness," $60,802.00, funded by NSF FREEDM Energy Research Center (NSF EEC-0812121, 557412), 9/1/2013-8/31/2014.

A rigorous system level analysis on the stability, robustness and convergence of distributed control algorithms on FREEDM systems considering the interactions between the Distributed Control algorithms and the FREEDM Power Management and Control through SST.

[22] Title: "Fundamental Science: Control of the FREEDM System," $60,802.00, funded by NSF FREEDM Energy Research Center (NSF EEC-0812121, 529670), 9/1/2013-8/31/2014.

A rigorous system level analysis on the stability, robustness and convergence of the distributed control algorithms on FREEDM systems considering the interaction of Distributed Control algorithms with DGI/RSC plug-and-play platform / operating environments including communication protocols and operation resources and communication imperfections.

[23] Title: "iSpace Technology," $50,000.00, funded by NSF I-Corps program (NSF Award Number 1338371, NCSU # 556231), April 15 2013 – October 30, 2013.

The iSpace technology developed by Advanced Diagnosis, Automation, and Control (ADAC) Lab at the North Carolina State University (NCSU) provides a solution to meet the demands for efficiency, scalability, security and robustness in the control and management of cyber-physical industrial applications, such as transportation systems, energy management system and power grids. In this project, we investigate and identify the potential customers and the appropriate markets and test the commercial feasibility of iSpace technology on Battery Management Systems through this Innovation Corps project.

[24] Title: "Active Balancing on the Basis of Cell's State-of-Charge (SOC)," $84,999.00, funded by Samsung Co., 7/1/2012 – 7/31/2013.

This project investigate:
1. Feasible SOC estimation method selection: To compare different approaches proposed to estimate the SOC and propose a feasible one based on well-defined performance indexes.
2. Cell unbalancing phenomena characterization: To characterize and categorize Cell unbalancing phenomena based on the SOC and other measurements and information from the battery pack cells.

[25] Title: "Plug-and-Play Topology and Impedance Identification," $37,409.00, funded by NSF FREEDM Energy Research Center (NSF EEC-0812121, 529670), 9/1/2012-8/31/2013.

This project will investigate a FREEDM system plug-and-play function for automating updates in feeder circuit topology and impedance modeling when a new device is added or the circuit is reconfigured.

[26] Title: "Distributed Control of FREEDM System," $268,993.00, funded by NSF FREEDM Energy Research Center (NSF EEC-0812121, 529670), 9/1/2008-8/31/2013.

This project investigates and develops distributed control algorithms on a pilot simulation-based project to demonstrate the salient features of a FREEDM system and the corresponding intelligence/algorithms. The resulting software needs to be expandable and compatible with the FREEDM Green Hub simulator and the actual FREEDM Green Hub.

[27] Title: Development of Distributed Energy Storage Device (DESD) / On-Line Battery Monitoring, funded by NCSU Advanced Transportation Electric Center (ATEC), 9/1/2013-12/31/2013, $25,000.00.

State-of-Charge (SOC) of the battery pack will be estimated in each step using online battery parameters identification and state estimation. The identified parameters of the battery will be used to estimate the ageing effect or State-of-Health (SOH) of the battery pack and provide appropriate warning alarms.
News: The work is highlighted on 2010-10-10 Science360, NSF's official news site: http://news.science360.gov/archives/20121010.

[28] "Collaborative Research: GOALI: AIS gene library based real-time resource allocation on time-sensitive large-scale multi-rate systems," (with Timothy Chang at NJIT and Simon Cobb at NCCAR) $197,534.00 for NCSU, and $197,534.00 for NJIT, funded by NSF ECCS-0823952, 9/01/2008 – 8/31/2012.

This project uses Gene Library to classify and detect abnormality in vehicle movements in various traffic environments and to provide optimal real-time sampling rate adaptations and emergency interventions. The gene library stores relevant information in the memory for real-time fetching to avoid on demand optimization and computation. Artificial Immune Systems (AIS) optimization is used to tune the gene library so that the gene library can be used in real-time as well as can adapt

to its environment for optimal solutions. The primary purpose is to prevent accident caused by abnormal behavior of the impaired drivers during driving.

[29] "Intelligent Energy Management Systems for PHEV Municipal Parking Charging Station," funded by ATEC (Advanced Transportation Energy Center), Aug 16, 08 – Aug 15, 12, ~ 80,000/year (2 Grad students and one month summer salary, charge to an 6-account managed by Alex Huang as Advanced Transportation Electric Center), expected to be renewed annually. Prime: Advanced Transportation Electric Center (ATEC) (Part of the team, Director: Alex Huang) $1,000,000.00 annually, funded by Progress Energy, Duke Energy, NC Government, August 2008 - 2012.

Develop intelligent Energy Management Systems (iEMS) and effective PHEV battery models for PHEV Municipal Parking Charging Stations.

[30] "Small World Stratification for Power System Fault Diagnosis with Causality," (with Simon Hsiang) $240,000.00, funded by NSF 0653017, 9/1/2007 – 8/31/2011.

To investigate and develop a fault diagnosis with causality methodology for power distribution systems using Small World (SW) strategy and Hierarchical Clustering (HC) technology to substantially improve fault diagnosis accuracy and reasoning. The proposed work provides a general framework from which to evaluate cases with similar symptoms, geographical settings and topological connectivity for the fault diagnosis and will give the context for causality.

[31] "Algorithms and Structures For Self Healing Circuits (Healic)," (with Paul Franzon (PI), Michael Steer) subcontracted by Raytheon TI Systems from DARPA, ," $2,219,687.00, pre-awarded, anticipating my share, ½ summer and 5.5% release time, Jan 1, 2009 – Dec 31, 2012.

[32] "Massive Sensor Based Congestion Management System for Transportation System," (with Janice Daniel, Timothy Chang at NJIT) funded by FHWA Transportation Planning Cooperative Research, Department of Transportation, $33,405.00 for NCSU (subcontracted from NJIT), June 15 2008 – June 14 2009.

Seed project to identify the quantitative requirements for implementing congestion planning using massive real time, sensor data. To investigate data gathering using probe vehicles, data transmission using wireless communications, massive data processing, and model building to analyze congestion relief strategies for near- and long-term planning purposes.

[33] "Plug Hybrid Electric Vehicle (PHEV) Smart Charging," funded by Progress Energy (Gift approach), $24,000.00, Aug. 16, 2007 – August 15, 2008.

Seed money to establish a PHEV Smart Charging Laboratory at North Carolina State University with the following capabilities:

Able to effectively test various type of PHEV system charging,
Able to effectively test various type of PHEV charging algorithms,

[34] "Power distribution system analysis," $46,171.00, funded by Quanta Technologies (Gift approach) 5/16/07 – 8/15/08.

Perform Power Distribution Systems analysis and software development.

[35] "Time- and Data-Sensitive Wireless Networked Control Systems," (with Wenye Wang), $239,808.00, funded by National Science Foundation (NSF 0524519), 09/01/2005 – 12/31/2009.

Integrate networked control techniques and wireless communication technologies for real-time, remote monitoring and control.

[36] Intelligent Space at North Carolina State University – unfunded project, 8/16/04 - present

This project combines several engineering disciplines including Image Acquisition and Processing, Mechatronics and path tracking algorithms to monitor an area so that a UGV (unmanned ground vehicle) can be intelligently guided by distributed controllers to reach its destination optimally without colliding with obstacles in the space.

[37] "A joint exploratory study on the applicability of Networked Control Systems for critical Multi-variable Systems," $8,591.00, 8/15/06 – 7/31/07, funded by NSF.

This project proposal proposes an exploratory study, which is the intellectual merit of this project, on the applicability of NCS (Networked Control Systems) for process plants like thermal and nuclear power plants and/or chemical reactors. The research group from the North Carolina State

University, headed by Prof. Mo-Yuen Chow and the research team from Jadavpur University headed by Dr. Amitava Gupta, shall interact within the scope of this exploratory study with one doctoral student from each side to study the applicability of Networked Control Systems to complex industrial processes. The results of this exploratory study shall identify re-usable technology modules that can be used in the ongoing projects of both the collaborators and pave the way for a future joint R&D project."

[38] "Improved Classifiers for Fault Diagnosis," $8,308.00, funded by Intelligent Automation, Inc., 8/16/2005 – 12/31/2005.

Conduct literature search for the ongoing projects in the Signal Processing Group of IAI in the fields of signal processing, image processing and condition monitoring. The literature search results will be documented in the form of literature survey and related work in order to assist the IAI projects.

[39] "Intelligent Human-Machine Interface & Control for Highly Automated Chemical Screening Processes," (with David Kaber, Robert St. Amant), $786,000.00, funded by National Science Foundation (NSF 0426852), 10/1/2004 – 9/30/2008.

The *breakthrough information technology* that we will develop through this ITR project is an intelligent/adaptive, human-machine interface to support the new role of screening process supervisors in safe and effective, distributed control of high time stress and high risk, automated chemical and toxicity testing. The development of this technology will be based on cognitive modeling of supervisory controller behaviors during actual chemical screening processes and model predictions of operator performance with different interactive information display design alternatives during the (model) design phase and during chemical process run-time. We will prototype control interfaces and shared situation awareness displays for operators that integrate and display process output data adapted to operator concurrent performance needs and functional (physiological) states.

[40] "Biologically Inspired Intelligent Fault Diagnosis for Power Distribution Systems," $150,000.00, funded by National Science Foundation (NSF 0245383), 5/15/2003 – 12/31/2007.

This project will investigate and develop a Biologically Inspired Intelligent Fault Management System using Artificial Immune System (AIS) technologies on top of a Neural Network - Fuzzy Logic (NN-FZ) structure to *actively manage* ***power distribution system*** *faults*, including diagnosis, prognosis, and data mining. This system would revolutionize the Fault Diagnosis process for power distribution systems, to significantly increase system reliability and reduce operation costs. The proposed activities and architectures are not only limited to power distribution system, but are also applicable to other industries such as communication networks and transportation system that are large scale nonlinear system with uncertain operating environments.

[41] BD Technology, "Scheduling and fault detection of BD robotics platform (Discovery Platform)," $22,000.00, 6/1/06 – 12/31/06.

A demonstration project to review automation capabilities and the different components of a robotic line. Develop a conceptual diagram of how the system components interact together as the basis of a computer model and develop a software simulator of how the system works.

[42] Immune System Inspired Fault Detection Diagnosis and Prognosis of Dynamical Systems, NCSU ECE PhD Research, 8/16/02 – 12/31/05.

In this project, the objective is to develop a hybrid intelligent method for fault detection, diagnosis and prognosis of rotational machinery using immune system inspired concepts on top of Artificial Neural Networks and Fuzzy Logic technologies. Bearing fault, which is one of the most common rotational machinery faults, is chosen as the testbed fault.

[43] "Towards an International Research Partnership program on Human-Automation interaction in the life sciences," (with David Kaber, Robert St. Amant, Robert Kelly, Leonard Bull) $58,699.00, funded by National Science Foundation (NSF), 9/1/04 – 8/31/05.

To develop a large "international research partnership program" proposal is to develop a collection of small, integrated research projects at NCSU in bioinformatics that will complement an integrated set of projects on life sciences automation to be conducted at CELISCA. The idea behind the proposal is that the two universities may be able to define a large high-throughput

screening process through the linkage of biocatalysis and high-performance analytical chemistry facilities at CELISCA and microarray research facilities at NCSU.

[44] "Algorithms for Next-Generation UAV community benchmark testing and evaluation," $40,000.00, funded by the National Institute of Aerospace and NASA LaRC, 1/1/04 – 11/30/05.

The objective of this project is to generate the algorithms required to perform the benchmark testing to evaluate the next-generation Unmanned Aerial Vehicle (UAV) control systems and required hardware realizations.

[45] "Hybrid Electric Vehicle Modeling, Simulation and Prognostics", $29,367.00, funded by U.S. Army, TACOM TARDEC Division, 5/6/03 – 12/31/03.

Modeling and simulation studies to assess potential advantages of Hybrid Electric Architecture for Future Combat System with respect to mobility, fuel economy, and improved prognostics.

[46] National Science Foundation Division on International Program - JSPS (Japan Society for the Promotion of Science) Short-term Invitation Fellowship on "Application on IP-based smart space and network control systems," approximately $12,000.00, June 2003 – February 2004.

To establish research project between Advanced Diagnosis and Control Laboratory at North Carolina State University with the Intelligent Control System Laboratory (directed by Dr. Hideki Hashimoto) at University of Tokyo on the topic of "IP-based smart space and network control systems".

[47] Network-Based Control, PI: Mo-Yuen Chow, Graduate Student Fellowship, supporting two Ph.D. students – Yodyium Tipsumwan and Naif Bejad Al-Mutairi full tuition and stipend, approximate $60,000.00/year , 1/1/99 – 8/15/03.

The purpose of this research has been to investigate network delay effects on networked control systems and to develop a control methodology to handle the network delay effects using optimal gain scheduling. The proposed gain scheduling technique adapts controller gains externally by modifying a controller output to enable the controller for uses over a network. This project has investigated, analyzed, and developed real-time on-line intelligent gain adaptation scheme for a network-based controller system under normal and abnormal operating conditions to maximize the *closed-loop* system performance and stability.

[48] Web-Based Virtual Unmanned Vehicle Simulator Development for Distance Learning Courses, funded by Distance Education & Learning Technology Applications (DELTA), $12,000, 1/20/03 – 6/30/03.

In this Delta Grant project, we propose to develop a Web-based Virtual Unmanned Vehicle Simulator that can be accessed through the web for the Distance Learning (DL) students to prototype (in software) their control algorithms and mechatronics circuits to control the unmanned vehicle (simulation) before they actually test their design on an actual unmanned vehicle (hardware).

[49] Real Time Wireless Controlled Robot, NCSU ECE MS Independent Research, 8/16/02 – 5/15/03.

The objective of this project is to create a wireless controlled path-tracking robot. The entire project was divided into four phases of development. First, a hardware platform is required for a differential drive mobile robot. Second, the robot will need a "hard" real-time hardware controller that will be used to drive the robot. The third phase is to implement a robust path tracking control algorithm. Lastly, the robot will need to come to live by implementing wireless capabilities. Each phase of this project evolves in knowledge regarding circuits, embedded systems, programming, and control engineering.

[50] Web-Based Remote Access Real-Time Mechatronics Laboratory Development, funded by Distance Education & Learning Technology Applications (DELTA), $16,600, 1/1/02 – 6/30/02.

This project develops a Web-based remote access real-time Mechatronics Lab, as shown in Figure 1, to enable Distance Learning students interested in Mechatronics to receive the full benefits of a high quality Mechatronics education comparable to the one received for on-campus students.

[51] A Novel Set Theoretic Based Neural/Fuzzy Network Traffic Feature Extraction and Modeling Methodology," with Arne A. Nilsson, H. Joel Trussell, funded by Center for Advanced Computing and Communication (CACC), $72,104, 7/1/00 – 6/30/02.

The objective of this project is to develop a novel methodology using *Set Theoretic* and *Neural/Fuzzy Systems* which can adaptively classify and model network traffic both in transient and steady state conditions.

[52] Proactive Intelligent Network Fault Management, PI: Mo-Yuen Chow, funded by Nortel Co., $68,000, 10/1/00 – 12/31/01.

The objective of this project is to investigate and develop a real-time proactive intelligent fault management system for communication networks to assess real-time system incipient fault conditions and actively control the system to minimize further system degradation while maintaining the best possible system performance and availability.

[53] Motor Electric Spark Noise Analyses and Characterizations, PIs: Mo-Yuen Chow, Joel Trussell, funded by Buehler Motor Co., $25,000.00, 7/1/00-6/30/01.

The objective of this project is to develop an enhanced diagnostic scheme for the cause and characterization of motor noises using advanced digital signal processing and control modeling.

[54] International Collaboration Grant, funded by NCSU $5,000.00, 7/1/98-6/30/00.

Establish research and education institution relation between NCSU and Tsinghua University in China.

[55] Communication System Network Control Software Performance Modeling and Fault Detection, with Arne Nilsson, funded by Center for Advanced Computing and Communication (CACC), $14,634.00, 7/1/98-6/30/99.

[56] A Neural/Fuzzy Approach for Motor Incipient Fault Detection, PI: Mo-Yuen Chow, Co-PI: Joel Trussell, funded by National Science Foundation (NSF), $180,000.00, 8/1/95-7/30/99.

This project investigates different significant factors such as varying load conditions, saturation effects, noise effects, and their influences on motor incipient fault detection for three-phase induction motors. A goal is to establish a general theory and principle for motor incipient fault detection using set theoretic formulation. Neural networks and fuzzy logic are used to obtain accurate motor fault detection in a non-invasive, economical, and reliable manner. In addition, the method provides a qualitative and heuristic explanation of the fault detection process.

[57] NSF REU for A Neural/Fuzzy Approach for Motor Incipient Fault detection, PI: Mo-Yuen Chow, Co-PI: Joel Trussell, funded by National Science Foundation, $9,993.00, 6/30/97 - 7/31/99.

The requested grant supplement will be used to support two undergraduate students at North Carolina State University to work on the project *A Neural/Fuzzy Approach for Motor Incipient Fault Detection*. The students will explore and be trained in the research areas of rotating machinery and fault detection, artificial neural networks and fuzzy logic, assist research, and implement the developed neural/fuzzy motor fault detection algorithm in LABVIEW on a PC interfaced with a test motor connected to a load.

[58] Engineering Research Equipment Fast Prototyping System for Motor Incipient Fault Detection, PI: Mo-Yuen Chow, Co-PI: Joel Trussell, funded by National Science Foundation, $74,627.00, 5/15/95-7/31/99.

The Fast Prototyping System for Motor Incipient Fault Detection equipment is used for several research projects. The main research project to be supported from this equipment grant is: A Neural/Fuzzy Approach for Motor Incipient Fault Detection. There are also several research projects which benefit from this research equipment grant. The equipment can provide actual data for the *Fast Prototype Motor Simulation System* project.

[59] Incipient Fault Detection and Diagnosis of Communication Software and, with Arne A. Nilsson, funded by Center for Advanced Computing and Communication (CACC), $15,062.00, 1/ 1/98 - 6/30/98.

This project develops error propagation models for different network software based on the fault records, software module topology such as fan-in and fan-out structure, and software used, and developing fault detection and diagnosis techniques to locate which piece of software is causing the problem.

[60] Communication System Network Control Software Reliability, with Arne A. Nilsson, funded by Center for Advanced Computing and Communication (CACC), $8,819.00, 7/ 1/97 - 6/30/98.

This project investigates the differences among fault symptoms in the fault records caused by software failure and hardware failure; and develop reliability models for different network software based on the fault records, network topology, hardware configurations, and software used.

[61] Power Quality Assessment of Power Distribution Systems, funded by Electric Power Research Center (EPRC), $17,800.00, 1/ 1/98 - 12/31/98.

The project investigates the issue of power quality – including both transient and steady-state conditions, with emphasis on voltage sags and voltage distortions, and its influence on the local distribution system in terms of the relationship between the power distribution system and the motor-drive system. The resultants of this project are mathematical models and software packages that can be used to assist power suppliers (e.g.: utilities, independent power generation parties) and customers' facilities (e.g.: as manufacturing plants and computer networks) to evaluate power quality problems quantitatively and to estimate the benefits of potential mitigation methods.

[62] Distribution System Load Management, with Mesut Baran, funded by Electric Power Research Center (EPRC), $38,800.00, 1/1/97 - 12/31/97.

Unbalanced feeder systems cause deteriorating power quality and increase investment and operating costs. For an unbalanced feeder system, feeder reconfiguration is difficult to meet the phase balancing criterion due to the limited number of sectionalizing switches available. Phase swapping is another alternative and direct approach for phase balancing. Phase swapping can economically and effectively balance the feeder systems to improve power quality and reduce power system total cost. Deregulation arises competition on power quality, service reliability, and electricity price. Therefore phase swapping can enhance utilities competitive capability. This project investigates different optimization approaches to solve the phase balancing problems.

[63] Fast Prototype Motor System Simulation, PI: Mo-Yuen Chow, funded by Electric Power Research Center (EPRC), $24,400.00, 1/1/96 - 12/31/97.

The objective of this project is to develop a fast prototype software system and novel modeling methodologies to accurately simulate motor performance under different control and operation conditions. The basis for the FPMS program has: graphic interface, data management, software simulation, and hardware/software interface. With the use of this new software platform and novel modeling techniques, users can use this system to simulate and analyze the time-domain motor performances for different power system settings, or simulate and test the motor control and fault detection algorithms being designed and developed, in a time-efficient and cost effective manner.

[64] Estimated Time of Restoration, PI: Mo-Yuen Chow, funded by Electric Power Research Center (EPRC), $14,800.00, 1/1/95 - 12/31/95.

This project algorithms and computer programs to provide an optimal estimate of outage restoration time based on appropriate and available information for improving distribution operation efficiency and cost effectiveness.

[65] Power Distribution Fault Location and Diagnosis, PI: Mo-Yuen Chow, funded by Duke Power Company, $65,369.00, 10/1/94-12/31/95.

[66] Motor Fault Detection, PI: Mo-Yuen Chow, funded by Electric Power Research Center (EPRC), $8,000.00, 1/1/95 - 12/31/95.

[67] Drive System Components Evaluation, PI: Mo-Yuen Chow, funded by APV Baker, Inc., $6,239.00, 11/1/94 - 1/31/95.

[68] Smart Relay, PI: Mo-Yuen Chow, funded by Electric Power Research Center (EPRC), $10,000.00, 1/1/94 - 12/31/94.

[69] Application of Neural Networks in Power Engineering/Finding Exact Causes of Distribution Faults, PI: Mo-Yuen Chow, funded by Electric Power Research Center (EPRC), $18,000.00, 1/1/94 - 12/31/94.

[70] NSF Engineering Faculty Internships Initiatives, PI: Mo-Yuen Chow, funded by National Science Foundation and Duke Power Company, $21,894.00, 9/1/93 - 8/31/94.

[71] Enhancement grant of Finding Exact Causes of Distribution Faults, PI: Mo-Yuen Chow, funded by Duke Power Company, $15,000.00, 1/1/93 - 12/31/93.

[72] Intelligent Energy Control, PI: Mo-Yuen Chow, funded by Electric Power Research Institute (EPRI), $150,000.00, 1/1/92 - 12/31/95.

The proposed intelligent energy controller uses a real time system identification technique and an *optimal control* approach. It aims toward an intelligent control scheme that can self adapt by monitoring some easily accessible parameters, such as temperature and humidity in the building and power consumption of the HVAC system of the building. The objective of this project is to develop an *load demand-side intelligent energy control system* for a building to maximize comfortability and minimize energy and cost.

[73] Application of Neural Networks in Power Engineering/Finding Exact Causes of Distribution Faults, PI: Mo-Yuen Chow, funded by Electric Power Research Center (EPRC), $45,700.00, 1/1/91 - 12/31/93.

[74] Incipient Fault Detection of Rotating Machines Using Neural Networks, PI: Mo-Yuen Chow, funded by National Science Foundation, $ 119,000.00, 7/15/90 - 12/31/93.

[75] Distribution Capacitor Fault Detection Using Artificial Neural Networks, PI: Mo-Yuen Chow, funded by US Army Corps of Engineers — Construction Engineering Research Lab, $ 45,000.00, 1/1/91 - 5/15/93.

[76] Enhancement grant of Finding Exact Causes of Distribution Faults, PI: Mo-Yuen Chow, funded by Duke Power Company, $16,000.00, 1/1/91 - 12/31/92.

[77] Induction Motor System Identification, PI: Mo-Yuen Chow, funded by Square D Company, $18,000.00, 7/1/90 - 12/31/90.

[78] Application of Neural Networks in Power Engineering/Incipient Fault Detection of Rotating Machines Using a Neural Networks, PI: Mo-Yuen Chow, funded by Electric Power Research Center (EPRC), $65,500.00, 1/1/89 - 12/31/90.

[79] Analysis of Distribution Feeder Load Under Varying Voltage Conditions, PI: Mo-Yuen Chow, funded by Electric Power Research Center (EPRC), $12,800.00, 1/1/88 — 12/31/88.