# Xi-Ren Cao

**AFFILIATION:**

Department of Electrical and Electronic Engineering
The Hong Kong University of Science and Technology
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**EDUCATION:**

Ph.D. in applied mathematics, Harvard University, 1984
M.S. in engineering, Harvard University, 1982
B.S. in physics, University of Sciences and Technology of China, Beijing, 1967

**ACADEMIC EXPERIENCE:**

**Chair Professor**, 2005 - (Among the first group established in 2005)
**Professor/reader**, (Reader Oct. 1993 - 1996, Prof. 1996 -)
**Director of Center for Networking**, 1999 -
**Director of Postgraduate Programme**, 1994 - 1996

   Dept. of EE Eng., The Hong Kong Univ. of Sci. & Tech., Hong Kong

**Visiting Professor**, Jan. - June 1998

   Institute of Systems Research, Univ. of Maryland at College Park, U.S.A.

**Visiting Professor**, Fall 1991, Univ. of Mass. at Amherst, U.S.A.

   Taught a graduate course: *Control and Optimization of Stochastic Systems*

**Visiting Professor**, Spring 1989, Harvard University, U.S.A.

   Taught a graduate course: *Modeling and Analysis of Discrete-Event Systems*

**Adjunct, Visiting, Consultant Professor**, Nankei University, University of Science and Technology of China, Shanghai Jiaotong University, Tsinghua University, Tongji University, etc., China,

**Research Fellow**, January 1984 - April 1986, Harvard University
Engaged in research on control theory, perturbation analysis of discrete-event dynamic systems, decision theory, and stochastic approximation problems

**INDUSTRIAL/GOVERNMENT EXPERIENCE:**

**Expert**, Sept. 1998 - Dec. 1998, Commission of Inquiry on the New Airport, Hong Kong

**Special Consultant,** Sept. 1 - Dec. 31, 1997

   Teletraffic and Performance Analysis Dept., AT&T Labs, Holmdel, NJ, U.S.A.

**Supervisor/Manager, Principal/Consultant Engineer**, May 1986 - Sept. 1993

   Digital Equipment Corporation, Massachusetts, U.S.A.

- Established and managed the VAXcluster Performance Group. Led and directed the performance analysis of integrated systems consisting of FDDI, Ethernet, and GI-GAswitchs. Introduced new discrete event systems modelling techniques to DEC. Invented new algorithms for bus arbitration which resulted in increased efficiency of 30%; Lead and participated the performance testing of several large integrated systems, such as NASDAQ and New York police emergency system. Continued fundamental research

in the areas of discrete event systems, stochastic optimization, and computer communication systems.

**Consultant**, 1984-1986, Network Dynamics Inc., Cambridge, Mass. U.S.A.

**Worker and Technician,** 1968-1978, Daye, Hubei, China

## UNIVERSITY SERVICES:

- Advisory Peer Group, The Open University of Hong Kong, 2000-2008.

- University Senator, 1994 - 1996

- Acting Chairman and Member, University Student Disciplinary Committee, 1996

- Member, University Honorary Degrees Committee, 1996 - 1998

- Member, University Postgraduate Studies Committee, 1996 - 1998

- Member, University Technology Review Committee, 1997 -

- Chairman (2002- ), Member(2000-2002), School of Engineering Substantiation and Promotion Committee.

- Served as acting department head, and in the Faculty Search Committee, Academic/ Substantiation Review Committee at the departmental level, 1993-1998

## HONORS AND AWARDS:

- Outstanding Service Award, IFAC (International Federation of Automatic Control), 2008

- Fellow of IFAC, 2008

- Fellow of IEEE, 1996

- Outstanding Simulation Publication Award, The College of Simulation, The Institute of Management Sciences (TIMS), co-authored with P. Heidelberger, et al. 1990

- Outstanding Transactions Paper Award, IEEE Control System Society, 1987
  Comments on the winning paper: *"This is a landmark paper laying the foundation for infinitesimal perturbation analysis and providing a stimulus for many subsequent results."*

- Best Student Paper Award, IEEE Control System Society, 1982

## RESEARCH ACTIVITIES:

### Director of Computer Networks and System Integration Laboratory:

Established the CNSI Lab equipped with Digital alpha servers, gigabit FDDI switches, Sun workstations, Newbridge ATM switches, AT&T Exchanges, etc; conducted research in ATM telephony, computer system integration, etc; established cooperation with Digital, Hong Kong Telecom, Newbridge, and China Telecom, etc.

### Research Areas:

- Learning and optimization theory, stochastic approximation

- Discrete event dynamic systems, perturbation analysis

- Data and tele-communications, optical and wireless communication

- Signal processing, blind signal separation, blind channel equalization

- Manufacturing, scheduling

- Performance analysis, stochastic processes, queueing theory

- Financial engineering, Internet pricing, Incentives in electrical power transaction systems

## PROFESSIONAL ACTIVITIES:

### Committee Member and Chairmanship:

- Vice President (founding), Asian Control Association, 2006 - .

- Chairman, IEEE Fellow Evaluation Committee, IEEE Control Systems Society, 2005 - 2006; Member 2002-2004

- Chairman, Coordinating Committee on Systems and Signals, International Federation of Automatic (IFAC), 2004-2011

- Member, IFAC Technical Board, 2004-2011

- Board of Governors, IEEE Control System Society, 2000 (appointed), and 2004-2006 (elected)

- Chairman, Technical Committee on Discrete Event Dynamic Systems, International Federation of Automatic Control (IFAC), 1996 - 2002

- Chairman, Technical Committee on Networks and Communications, IEEE Control Systems Society, 1993 - 1997

- Member, Technical Committee on Blind Digital Signal Processing, IEEE Circuits and Systems Society, 2002-

- Vice-Chairman, IEEE Hong Kong Joint Chapter of RA/CS, 1994 - 1997

### Editorship:

- Editor-in-Chief, Discrete Event Dynamic Systems: Theory and Applications, 2005 - Associate editor, 1989 - 2005

- Associate editor at large, IEEE Transactions on Automatic Control, 1999 -

- Associate editor, Automatica, 2001 - 2004

- Editor, Communications in Information and Systems, 2000 -

- Area editor, Intl Journal of Operations and Quantitative Management, 1995 - 2003

- Associate editor, IEEE Transactions on Control Systems Technology, 1992 - 1994

- Associate editor, IEEE Transactions on Automatic Control, 1988 - 1990

- Associate editor, Control Theory and Applications, 1996 -

- Associate editor, Journal of Systems Science and Complexity, 2000 -

- Honorary editor, Journal of Data Acquisition and Processing, 1999 -

- Overseas Editorial Member, Frontiers in China, Electrical and Electronic Engineering, 2005 -

**Conferences:**

- Vice Chairman, International Program Committee, 1999 Triennial World Congress, International Federation of Automatic Control (IFAC), 1999

- Co-organizer and Co-chairmen, Workshop on System and Control Issues in Communication Networks (co-sponsored by NSF and ARO, etc) Airlie, Virginia, August 1996

- General Chairman, 1994 Hong Kong International Workshop on New Directions of Control and Manufacturing, 1994

- Member of program committees of many international conferences including 1993, 1994, 1996 IEEE Conference on Decision and Control (CDC), 1995 American Control Conference, 1991 IEEE Conference on Robotics and Automation, 1993 ORSA Telecommunication Conference, etc (not listed here, average 2-3 per year)

- Co-organizer and co-instructor (with Y. C. Ho and C. Cassandras) Pre-conference workshop, *Discrete Event Dynamic Systems: The State of Art and New Directions*, 1989, 1992, 1994, 1997

- Chair and co-chair of sessions at IEEE CDC and other conferences since 1984

- Advisory/steering committee member, Chinese Control Conference, Asian Control Conference, International Workshop on Discrete Event Systems (2004-2010), Chinese Control and Decision Conference (2008-2009), World Congress on Intelligent Control and Automation.

**Plenary Talks:**

- 17th IFAC Triennial World Congress, Seoul, Korea, 2008

  *"Stochastic Learning and Optimization - A Sensitivity-Based Approach"*

- 20th Chinese Control and Decision Conference, Yantai, China, 2008

  *"Limitation of Markov Models and Event-Based Learning and Optimization"*

- The Inaugural IEEE Multi-conference on Systems and Control, Singapore, 2007

  *"Limitation of Markov Models and Event-Based Learning and Optimization"*

- 8th International Workshop on Discrete Event Systems, Ann Arbor, Michigan, U.S.A., 2006

  *"Event-Based Stochastic Learning and Optimization"*

- 12th Mediterranean Conference on Control and Automation, Turkey, 2004

  *"A Map of the World of Learning and Optimization"*

- 17th International Symposium on Computer and Information Sciences, Orlando, Florida, U.S.A., 2002

  *"Gradient-Based Learning and Optimization"*

- 3rd Asian Control Conference, Shanghai, China, 2000

  *"Single Sample Path-Based Optimization Techniques"*

- Chinese Control Conference, Yellow Mountain, China

**Others:**

- Reviewer of National Science Foundation, U.S.A. and 20+ technical journals

- Panelist of National Science Foundation President Young Investigator Award, U.S.A., 1993

## PATENTS:

1. Blind Channel Equalizers and Methods of Blind Channel Equalization (U.S. Patent No. 6463099)

2. Shared Arbitration Apparatus Suitable for Deaf Node (U.S. Patent No. 5230044)

3. Arbitration Apparatus for Shared Bus (U.S. Patent No. 5239630)

## PUBLICATIONS:

**Books:**

3. **Xi-Ren Cao**, *Stochastic Learning and Optimization - A Sensitivity-Based Approach*, Springer, New York, 2007.

2. **Xi-Ren Cao**, *Realization Probabilities - The Dynamics of Queueing Systems*, Springer Verlag, New York, 1994.

1. Y. C. Ho and **Xi-Ren Cao**, *Perturbation Analysis of Discrete Event Systems*, Kluwer Academic Publishers, Norwell, MA, 1991.

**Journal Publications:**

109. **Xi-Ren Cao** and Junyu Zhang, Event-Based Optimization of Markov Systems, *IEEE Transactions on Automatic Control,* to appear.

108. **Xi-Ren Cao** and Junyu Zhang, The nth-Order Bias Optimality for Multi-chain Markov Decision Processes, *IEEE Transactions on Automatic Control,* Vol. 53, 496-508, 2008.

107. Kan-Jian Zhang, Yan-Kai Xu, Xi Chen and **Xi-Ren Cao**, Policy Iteration Based Feedback Control, *Automatica*, Vol. 44, 1055-1061, 2008.

106. **Xi-Ren Cao** and Xianping Guo, Partially Observable Markov Decision Processes with Reward Information: Basic Ideas and Models, *IEEE Transactions on Automatic Control,* Vol. 52, 677-681, 2007.

105. **Xi-Ren Cao** and Junyu Zhang, Discussion on A Survey of Recent Results on Continuous-Time Markov Decision Processes, *TOP, Invited paper*, Vol. 14, 243-248, 2006.

104. Li Xie and **Xi-Ren Cao**, Relationship Between Perturbation Realization Factors with Queueing Models and Markov Models, *IEEE Transactions on Automatic Control,* 1699-1704, 2006.

103. Guoxiang Gu, **Xi-Ren Cao**, Hesham Badr, Generalized LQR Control and Kalman Filtering with Relations to Computation of Inner-outer and Spectral Factorizations, *IEEE Transactions on Automatic Control,* Vol. 51, pp. 595-605, 2006.

102. J. A. Zhao, B. Li, **Xi-Ren Cao**, and Ishfaq Ahmad, Matrix Analytic Solution for $DBMAP/PH/1$ Priority Queues, *Queueing Systems: Theory and Applications*, Vol. 53, 127-145, 2006.

101. Yat-wah Wan and **Xi-Ren Cao**, The Control of a Two-Level Markov Decision Process by Time Aggregation, *Automatica*, Vol. 42, 393-403, 2006.

100. Han-Fu Chen, **Xi-Ren Cao**, Hai-Tao Fang, and Jie Zhu, Nonlinear Adaptive Blind Whitening for MIMO Channels, *IEEE Transactions on Signal Processing, Part I*, Vol. 53, 2635-2647, 2005.

99. **Xi-Ren Cao**, A Basic Formula for On-line Policy-Gradient Algorithms, *IEEE Transactions on Automatic Control,* Vol. 50, 696-699, 2005.

98. Xianping Guo and **Xi-Ren Cao**, Optimal Control of Continuous-Time Markov Chains with Average Sample Path Rewards, *SIAM Journal on Control and Optimization*, Vol. 44, 29-48, 2005.

97. **Xi-Ren Cao**, Basic Ideas for Event-Based Optimization of Markov Systems, *Discrete Event Dynamic Systems: Theory and Applications,* Vol. 15, 169-197, 2005.

96. **Xi-Ren Cao**, The Potential Structure of Sample Paths and Performance Sensitivities of Markov Systems, *IEEE Transactions on Automatic Control,* Vol. 49, 2129-2142, 2004.

95. Bin Li, Lizhong Li, Bo Li, Krishna Sivalingam, and **Xi-Ren Cao**, Call Admission Control for Voice/Data Integrated Cellular Networks: Performance Analysis and Comparative Study, *IEEE Journal on Selected Areas of Communications*, special issue on all-IP wireless networks, Vol. 22, 706-718, 2004.

94. Jiangchuan Liu, Bin Li, Bo Li, and **Xi-Ren Cao**, Complexity and Heuristics for Wireless Broadcast with Noncumulative Layered Data, *IEEE Transactions on Wireless Communications*, Vol. 3, 2325-2334, 2004.

93. **Xi-Ren Cao**, Learning and Optimization - From a System Theoretic Perspective, *Handbook of Learning and Approximate Dynamic Programming*, J. Si, A. G. Barto, W. B. Powell and D. Wunsch II (eds), Wiley-Interscience, 311-336, 2004.

92. **Xi-Ren Cao** and Xianping Guo, A Unified Approach to Markov Decision Problems and Sensitivity Analysis with Discounted and Average Criteria: the Multichain Case, *Automatica*, Vol. 40, 1749-1759, 2004.

91. Hui Chen, Andrew Poon, and **Xi-Ren Cao**, Transparent Monitoring of Rise-Time Using Asynchronous Amplitude Histograms in Optical Transmission Systems, *Journal of Lightwave Technology,* Vol. 22, 1661-1667, 2004.

90. **Xi-Ren Cao** and Junyu Zhang, Performance Sensitivities for Parameterized Markov Systems, *Journal of Control Theory and Applications*, Vol. 2, 65-68, 2004.

89. Kin-On Cheng, Yu-Dong Zhu, **Xi-Ren Cao**, Danny H. K. Tsang, and Dennis T. K. Tong, Architecture for Optical-Burst Switch with WDM Shared Output Buffer, *Journal of Optical Networking*, Vol. 3, 417-432, 2004.

88. Hai-Tao Fang and **Xi-Ren Cao**, Potential-Based On-line Policy Iteration Algorithms for Markov Decision Processes, *IEEE Transactions on Automatic Control,* Vol. 49, 493-505, 2004.

87. **Xi-Ren Cao** and Bin Zeng, Invited book review: Structure and Interpretation of Signals and Systems by Edward A. Lee and Pravin Varaiya, Addison Wesley, 647 pages, *IEEE Transactions on Automatic Control,* Vol. 48, 1472-1474, 2003.

86. **Xi-Ren Cao**, Semi-Markov Decision Problems and Performance Sensitivity Analysis, *IEEE Transactions on Automatic Control,* Vol. 48, 758-769, 2003.

85. Bin Li, Lizhong Li, Bo Li, and **Xi-Ren Cao**, On Handoff Performance for an Integrated Voice/Data Cellular System, *ACM/Kluwer Wireless Networks (WINET)*, Vol. 9, 393-402, 2003.

84. **Xi-Ren Cao**, From Perturbation Analysis to Markov Decision Processes and Reinforcement Learning, *Discrete Event Dynamic Systems: Theory and Applications,* Vol. 13, 9-39, 2003.

83. **Xi-Ren Cao**, Introduction to the Special Issue on Learning, Optimization, and Decision Making in DEDS, *Discrete Event Dynamic Systems: Theory and Applications,* Vol. 13, 7-8, 2003.

82. **Xi-Ren Cao**, A Sensitivity View of Markov Decision Processes and Reinforcement Learning, *Modeling, Control, and Optimization of Complex Systems,* W. Gong and L. Shi (eds.) Kluwer Academic Publishers, 261-284, 2003.

81. **Xi-Ren Cao**, Performance Potential-Based Optimization and Markov Decision Processes, *Stochastic Models and Optimization*, D.D. Yao, H. Zhang and X.Y. Zhou (Eds.) 111-136, Springer, New York, 2002.

80. Y. C. Ho and **Xi-Ren Cao**, Sample Path Analysis of Discrete Event Systems, *The Encyclopedia of Life Support Systems (EOLSS)*, to appear.

79. **Xi-Ren Cao** and Junjie Wang, Obtaining Packet Response Times for Nonblocking ATM Switches, *Performance Evaluation*, Vol. 51, 33-45, 2002.

78. Bernd Heidergott and **Xi-Ren Cao**, A Note on the Relation Between Weak Derivatives and Perturbation Realization, *IEEE Transactions on Automatic Control*, Vol. 47, 1112-1115, 2002.

77. Han-Fu Chen, **Xi-Ren Cao**, and Jie Zhu, Convergence of a Stochastic Approximation Based Algorithm for Blind Channel Identification, *IEEE Transactions on Information Theory*, Vol. 48, 1214-1225, 2002.

76. **Xi-Ren Cao**, Hongxia Shen, Rodolfo Milito, and Patrica Wirth, Internet Pricing with a Game Theoretical Approach: Concepts and Examples, *IEEE/ACM Transactions on Networking,* Vol. 10, 208-216, 2002.

75. **Xi-Ren Cao**, G. Gohen, A. Giua, and W. M. Wonham, Unity in Diversity, Diversity in Unity: Retrospective and Prospective Views on Control of Discrete Event Systems, *Discrete Event Dynamic Systems: Theory and Applications,* Vol. 12, 253-264, 2002.

74. **Xi-Ren Cao**, Z. Y. Ren, Shalabh Bhatnagar, Michael Fu, and Steven Marcus, A Time Aggregation Approach to Markov Decision Processes, *Automatica*, Vol. 38, 929-943, 2002.

73. Hai-Tao Fang, Han-Fu Chen, and **Xi-Ren Cao**, Recursive Approaches for Single Sample Path Based Markov Reward Processes, *Asian Journal of Control*, Vol. 3 No. 1, 21-26, 2001.

72. **Xi-Ren Cao**, Junjie Wang, and Chin-Tau Lea, Computing MDP Cost Function for High Speed Networks with Sample-Path and Quantization, *Communications in Information and Systems*, Vol. 1, 147-162, 2001.

71. Bo Li, Yang Qin, **Xi-Ren Cao**, and Krishna M. Sivalingam, Photonic packet switchings: architecture and performance, *SPIE Optical Networks,* Vol. 2, No. 1, 27-39, Jan/Feb 2001.

70. Bo Li, Mounir Hamdi, Y. T. Hou, Dongyi Jiang, and **Xi-Ren Cao**, QoS Enabled Voice Support in the next generation Internet: Issues, existing approaches and challenges, *IEEE Communications Magazine*, Vol. 38, 54-61, 2000.

69. Han-Fu Chen and **Xi-Ren Cao**, Pole Assignment for Stochastic Systems With Unknown Coefficients, *Science in China (Series E)*, Vol.43, 313-323, 2000.

68. **Xi-Ren Cao**, A Unified Approach to Markov Decision Problems and Performance Sensitivity Analysis, *Automatica*, Vol. 36, 771-774, 2000.

67. Jie Zhu, **Xi-Ren Cao**, and R. -W. Liu, A Blind Fractionally-Spaced Equalizer with Joint Matrix Diagonalization, *IEEE Transactions on Circuits and Systems, II,* Vol. 46, 755-764, 1999.

66. Jie Zhu, **Xi-Ren Cao**, and Z. Ding, An Algebraic Principle for Blind Separation of White non-Gaussian Sources, *Signal Processing*, Vol. 76, 105-115, 1999.

65. **Xi-Ren Cao**, Michael C. Fu, and J. -Q. Hu, On Performance Potentials and Conditional Monte Carlo for Gradient Estimation for Markov Chains, *Annals of Operations Research*, Vol. 87, 263-272, 1999.

64. **Xi-Ren Cao**, Discrete Event Dynamic Systems (DEDS), Wiley *Encyclopedia of Electrical and Electronics Engineering,* Vol. 5, 602-612, 1999.

63. Jie Zhu, Zhi Ding, and **Xi-Ren Cao**, Column Anchored Zeroforcing Blind Equalization for Wireless FIR Channels, *IEEE Journal on Selected Areas of Communications*, Vol. 17, 411-423, 1999.

62. **Xi-Ren Cao**, Single Sample Path Based Optimization of Markov Chains, *Journal of Optimization: Theory and Application*, Vol.100, No.3, 527-548, 1999.

61. Dennis P. C. Iun and **Xi-Ren Cao**, Performance Analysis of a Nonblocking ATM Switch with a Bufferless Internal Speedup Fabric, *Computer Networks and ISDN Systems,* Vol. 30, 2337-2347, 1998.

60. **Xi-Ren Cao**, The Maclaurin Series for Performance Functions of Markov Chains, *Advances in Applied Probability*, Vol. 30, 676-692, 1998.

59. **Xi-Ren Cao**, The Relation Among Potentials, Perturbation Analysis, and Markov Decision Processes, *Journal of Discrete Event Dynamic Systems,* Vol. 8, 71-87, 1998.

58. **Xi-Ren Cao** and Yat-wan Wan, Algorithms for Sensitivity Analysis of Markov Systems through Potentials and Perturbation Realization, *IEEE Transactions on Control Systems Technology,* Vol. 6, 482-494, 1998.

57. **Xi-Ren Cao** and Han-Fu Chen, Potentials, Perturbation Realization, and Sensitivity Analysis of Markov Processes, *IEEE Transactions on Automatic Control*, Vol. 42, 1382-1393, 1997.

56. Han-Fu Chen and **Xi-Ren Cao**, Controllability is Not Necessary for Adaptive Pole Placement Control, *IEEE Transactions on Automatic Control*, Vol. 42, 1222-1229, 1997.

55. **Xi-Ren Cao**, X. M. Yuan, and L. Qiu, A Single Sample Path-Based Performance Sensitivity Formula for Markov Chains, *IEEE Transactions on Automatic Control*, Vol. 41, 1814-1817, 1996.

54. **Xi-Ren Cao**, Ensemble-Average Importance Sampling of Markov Processes, *International Journal in Computer Simulation*, Vol. 6, 489-512, 1996.

53. **Xi-Ren Cao** and D. J. Ma, Performance Sensitivity Formulas, Algorithms, and Estimates for Closed Queueing Networks with Exponential Servers, *Performance Evaluation,* Vol. 26, 181-199, 1996.

52. **Xi-Ren Cao**, Uniformization and Performance Sensitivity Estimation in Closed Queueing Networks, *Mathematical and Computer Modeling,* (invited paper) Vol. 23, No 11/12, 77-92, 1996.

51. **Xi-Ren Cao**, Perturbation Analysis of Discrete Event Systems: Concepts, Algorithms, and Applications, (invited Review) *European Journal of Operational Research,* Vol. 91, 1-13, 1996.

50. **Xi-Ren Cao** and R. -W. Liu, A General Approach to Blind Signal Separation, *IEEE Transactions on Signal Processing,* Vol. 44, 562-571, 1996.

49. **Xi-Ren Cao**, Event Coupling and Performance Sensitivity Analysis of Generalized Semi-Markov Processes, *Advances in Applied Probability*, 741-769, 1995.

48. **Xi-Ren Cao** and Don Towsley, A Performance Model for ATM Switches with General Packet Length Distributions, *IEEE/ACM Transactions on Networking*, Vol. 3, 299-309, 1995.

47. **Xi-Ren Cao**, W. G. Gong, and Y. Wardi, Ill-Conditioned Performance Functions of Queueing Systems, *IEEE Transactions on Automatic Control,* Vol. 40, 1074-1079, 1995.

46. **Xi-Ren Cao**, State Aggregation and Discrete-State Markov Chains Embedded in a Class of Point Processes, *Journal of Applied Probability*, Vol. 32, 39-51, 1995.

45. **Xi-Ren Cao**, The Maximum Throughput of a Non-blocking Space-Division Packet Switch with Correlated Destinations, *IEEE Transactions on Communications*, Vol. 43, 1898-1901, 1995.

44. **Xi-Ren Cao**, Performance Sensitivity Analysis of Open Markovian Queueing Networks, *European Journal of Operational Research,* Vol. 76, 529-551, 1994.

43. D. J. Ma and **Xi-Ren Cao**, Realization Factors and Decentralized Optimization of Jackson Networks, *Journal of Engineering,* Taiwan, No. 5, 87-98, 1994.

42. D. J. Ma and **Xi-Ren Cao**, A Direct Approach to Decentralized Control of Service Rates in a Closed Jackson Network, *IEEE Transactions on Automatic Control*, Vol. 39, 1460-1463, 1994.

41. **Xi-Ren Cao**, Infinitesimal Perturbation Analysis of Generalized Semi-Markov Processes: A Tutorial, (invited) *Discrete Event Systems*, G. Cohen and J.-P. Quadrat (Eds.) 401-408, Springer-Verlag, 1994.

40. **Xi-Ren Cao**, Some Common Misconceptions About Performance Modeling and Validation, *ACM Performance Evaluation Review*, Vol. 21, No. 2, 11-15, 1993.

39. **Xi-Ren Cao**, Decomposition of Random Variables with Bounded Hazard Rates, *Operations Research Letters,* Vol. 13, 113-120, 1993.

38. Yves Dallery and **Xi-Ren Cao**, Operational Analysis of Stochastic Closed Queueing Networks, *Performance Evaluation,* Vol. 14, 43-61, 1992.

37. **Xi-Ren Cao**, A New Method of Performance Sensitivity Analysis for non-Markovian Queueing Networks, *Queueing Systems: Theory and Applications*, Vol. 10, 313-350, 1992.

36. V. Abidi, D. J. Ma, and **Xi-Ren Cao**, Performance of the FDDI-based Vaxcluster Systems, *Vaxcluster Systems Quorum*, Vol. 7, Issue 3, 48-88, 1992.

35. **Xi-Ren Cao**, A Linear Algebraic Formulation of the Performance Sensitivities of Queueing Networks, *European Journal of Operational Research,* Vol. 56, 394-406, 1992.

34. **Xi-Ren Cao** and D. J. Ma, New Performance Sensitivity Formulae for a Class of Product-Form Queueing Networks, *Journal of Discrete Event Dynamic Systems,* Vol. 1, 289-313, 1992.

33. **Xi-Ren Cao**, Perturbation Analysis of Closed Queueing Networks with General Service Time Distributions, *IEEE Transactions on AC,* Vol. 36, 1327-1330, 1991.

32. **Xi-Ren Cao**, Some New Results on Realization Probability (Addendum to "A Comparison of the Dynamics of Continuous and Discrete Event Systems"), *Discrete Event Dynamic Systems: Analyzing Complexity and Performance in the Modern World,* edited by Y. C. Ho, 9-10, IEEE Press, 1991.

31. **Xi-Ren Cao** and D. J. Ma, Sensitivity Analysis of General Performance Measures of Queueing Networks with State Dependent Service Rates, *Applied Mathematics Letters*, Vol. 4, 57-60, 1991.

30. **Xi-Ren Cao** and Y. C. Ho, Models of Discrete Event Dynamic Systems, Invited paper for the *IEEE Control Systems Magazine,* Vol. 10, No. 6, 69-76, 1990.

29. **Xi-Ren Cao**, Realization Factors and Sensitivity Analysis of Queueing Networks with State Dependent Service Rates, *Advances in Applied Probability,* Vol. 22, 178-210, 1990.

28. **Xi-Ren Cao**, The Convergence Property of Sample Derivatives in Closed Jackson Queuing Networks, *Stochastic Processes and their Applications,* Vol. 33, 105-122, 1989.

27. **Xi-Ren Cao**, Estimates of Performance Sensitivity of a Stochastic System, *IEEE Trans. on Information Theory,* Vol. 35, 1058-1068, 1989.

26. **Xi-Ren Cao**, The Predictability of Discrete Event Systems, *IEEE Trans. on Automatic Control*, Vol. 34, 1168-1171, 1989.

25. **Xi-Ren Cao**, A Comparison of the Dynamics of Continuous and Discrete Event Systems, *IEEE Proceedings*, Vol. 77, 7-13, 1989.

24. **Xi-Ren Cao**, Realization Probability and Throughput Sensitivity in a Closed Jackson Network, *Journal of Applied Probability*, Vol. 26, 615-624, 1989.

23. **Xi-Ren Cao**, Calculation of Sensitivities of Throughputs and Realization Probabilities in Closed Queueing Networks with Finite Buffers, *Advances in Applied Probability,* Vol. 21, 181-206, 1989.

22. **Xi-Ren Cao**, System Representations and Performance Sensitivity Estimates of Discrete Event Systems, *Mathematics and Computers in Simulation*, Vol. 31, 113-122, 1989.

21. **Xi-Ren Cao**, The Static Property of a Perturbed Multiclass Closed Queuing Network and Decomposition, *IEEE Trans. on Automatic Control*, Vol. 34, 246-249, 1989.

20. P. Heidelberger, **Xi-Ren Cao**, M. Zazanis, and R. Suri, Convergence Properties of Infinitesimal Perturbation Analysis Estimates, *Management Science,* Vol. 34, No. 11, 1281-1302, 1988.

19. **Xi-Ren Cao**, Realization Probability in Multi-Class Closed Queuing Networks, *European Journal of Operational Research,* Vol. 36, 393-401, 1988.

18. **Xi-Ren Cao**, On a Sample Performance Function of Jackson Queueing Networks, *Operations Research,* Vol. 36, No. 1, 128-136, 1988.

17. **Xi-Ren Cao**, Feedback Invariant Discipline and Insensitivity in Closed Queueing Networks, *Systems and Control Letters,* Vol. 9, 349-353, 1987.

16. **Xi-Ren Cao**, Nii Quaynor, and Fernando Colon Osorio, CI Bus Arbitration Performance Study, *Digital Technical Journal,* No.5, 93-103, 1987.

15. **Xi-Ren Cao** and Y. C. Ho, Sensitivity Estimate and Optimization of Throughput in a Production Line with Blocking, *IEEE Trans. on Automatic Control,* Vol. 32, 959-967, 1987.

14. **Xi-Ren Cao**, Realization Probability in Closed Jackson Queueing Networks and Its Application, *Advances in Applied Probability,* Vol. 19, 708-738, 1987.

13. **Xi-Ren Cao** and Y. C. Ho, Estimating Sojourn Time Sensitivity in Queueing Networks Using Perturbation Analysis, *Journal of Optimization Theory and Applications,* Vol. 53, No. 3, 353-375, 1987.

12. **Xi-Ren Cao**, Sensitivity Estimates Based on One Realization of a Stochastic System, *Journal of Statistical Computation and Simulation,* Vol. 27, 211-232, 1987.

11. **Xi-Ren Cao**, First-Order Perturbation Analysis of a Single Multi-Class Finite Source Queue, *Performance Evaluation,* Vol. 7, 31-41, 1987.

10. **Xi-Ren Cao** and Yves Dallery, An Operational Approach to Perturbation Analysis of Closed Queueing Networks, *Mathematics and Computers in Simulation,* Vol. 28, 433-451, 1986.

9. Y. C. Ho and **Xi-Ren Cao**, Performance Sensitivity to Routing Changes in Queueing Networks and Flexible Manufacturing Systems Using Perturbation Analysis, *IEEE Journal of Robotics and Automation,* Vol. RA-1, 165-172, 1985.

8. **Xi-Ren Cao**, Convergence of Parameter Sensitivity Estimates in a Stochastic Experiment, *IEEE Trans. on Automatic Control,* Vol. AC- 30, 834-843, 1985.

7. **Xi-Ren Cao**, Discrete Event Dynamic Systems, *Acta Automatica Sinica,* Vol. 11, No. 4, 438-447, 1985.

6. Y. C. Ho, R. Suri, **Xi-Ren Cao**, and et al., Optimization of Large Multiclass (Non-product Form) Queueing Networks Using Perturbation Analysis, *Large Scale Systems,* Vol. 7, 165-180, 1984.

5. **Xi-Ren Cao**, The Dependence of Sojourn Times on Service Times in Tandem Queues, *Journal of Applied Probability,* Vol.21, 661-667, 1984.

4. Y. C. Ho, **Xi-Ren Cao**, and C. Cassandras, Infinitesimal and Finite Perturbation Analysis for Queueing Networks, *Automatica, 19, 4,* 439-445, 1983.

3. R. Suri and **Xi-Ren Cao**, The Phantom Customer and Marked Customer Methods for Optimization of Closed Queueing Networks with Blocking and General Service Times, *ACM Performance Evaluation Review,* 243-256, August 1983.

2. Y. C. Ho and **Xi-Ren Cao**, Perturbation Analysis and Optimization of Queueing Networks, *Journal of Optimization Theory and Applications,* 40, 4, 559-582, 1983.

1. **Xi-Ren Cao**, The Explicit Solution of the Unnormalized Conditional Probability Equation of a One-dimensional Linear System, *Systems and Control Letters,* Vol. 3, 13-22, 1983.

## Manuscripts under Review and Preparation:

1. Li Xia, Xi Chen, and **Xi-Ren Cao**, Policy Iteration of Customer-Average Performance in Queueing Systems.

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