

RAJESH P. N. RAO

Curriculum Vitae

June 2006

Work Address:
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POSITIONS

Assistant Professor, Department of Computer Science and Engineering, University of Washington (UW), 2000-present.

Faculty Member, Neurobiology and Behavior Program, UW, 2001-present.

Research Associate, Sloan Center for Theoretical Neurobiology, Salk Institute, 1997-2000. Advisor: Dr. Terrence Sejnowski.

Research Assistant, Department of Computer Science, University of Rochester, 1993-1997. Advisor: Dr. Dana Ballard.

Assistant Administrator, Macintosh Laboratory, Angelo State University, 1989-1992.

EDUCATION

Postdoctoral training in Computational Neuroscience, Sloan Center for Theoretical Neurobiology, Salk Institute, 1997-2000.

Ph.D. in Computer Science, University of Rochester, 1998. Dissertation title: *Dynamic Appearance-Based Vision*. Thesis Advisor: Dr. Dana Ballard.

M.S. in Computer Science, University of Rochester, 1994.

B.S. *summa cum laude* in Computer Science, Angelo State University, Texas, 1992.

B.S. *summa cum laude* in Mathematics, Angelo State University, Texas, 1992.

AWARDS

ONR Young Investigator Award, 2003-2006.

David and Lucile Packard Fellowship, 2002-2007.

NSF CAREER Award, 2002-2007.

Alfred P. Sloan Research Fellowship, 2001-2003.

Alfred P. Sloan Postdoctoral Fellowship, Salk Institute for Biological Studies, 1997-2000.

Presidential Fellowship for Graduate Studies, State University of New York, Buffalo, 1992 (declined in favor of Univ. of Rochester Graduate Assistantship).

Robert and Nona Carr Academic Scholarship for undergraduate study, Angelo State University, 1988-1992. *1991 Who's Who among students in American Colleges and Universities*. Alpha Chi (National Honor Scholarship), Epsilon Delta Pi (Computer Science), and Pi Mu Epsilon (Mathematics) 1991-1992.

Invited participant, Research Science Institute (RSI) program for high school students, Center for Excellence in Education, Virginia, 1987. Award Paper: *Epitaxy of high- T_c superconductors* (published in Proc. of RSI 1987). Second rank in Science in nationwide All-India high school examination (1986).

GRANTS

Neurally-Inspired Architectures for Invariant Object Recognition (Lead PI). NGA Neuroscience Enabled Geospatial Intelligence Program, 09/16/04.

Probabilistic Imitation Learning in Infants and Robots (Lead PI). NSF Artificial Intelligence and Cognitive Science program, 08/01/04.

Automatic Tactilization of Graphical Images: Full Access to Math, Science, and Engineering for Blind Students (Co-PI). NSF Universal Access program, 08/15/04.

Probabilistic Neuromorphic Systems (Lead PI). ONR Young Investigator Program, 05/01/03.

Probabilistic Brain-Computer Interfaces (Lead PI). David and Lucile Packard Fellowship, 11/01/02.

CAREER: Neurally Inspired Active Vision: Theory, Models, and Applications in Mobile Robotics (Lead PI). NSF Robotics and Human Augmentation program, 02/15/02.

Adaptive Neurally-Inspired Computing: Theory, Models, and Silicon-Based Architectures (Lead PI). NSF Biological Information Technology and Systems (BITS) program, 12/15/01.

Sloan Research Fellowship, 2001-2003.

TEACHING

Graduate course on Computational Neuroscience (Computational Neuroscience: CSE 528/NEUBEH 528), UW, Winter 2005. Textbook: Theoretical Neuroscience by Peter Dayan and Larry Abbott. Syllabus, slides, and course information: www.cs.washington.edu/education/courses/528/05wi/

Undergraduate course on Theory of Computation (Introduction to Formal Models in

Computer Science: CSE 322), UW, Autumn 2004, Spring 2004, Autumn 2002, and Autumn 2001. Textbook: Introduction to the Theory of Computation by Michael Sipser. Syllabus, slides, and course information: www.cs.washington.edu/education/courses/322/04sp/

Graduate course on Computational Neuroscience (Introduction to Computational Neuroscience: CSE 590RR), UW, Autumn 2003 and Spring 2002. Textbook: Theoretical Neuroscience by Peter Dayan and Larry Abbott. Syllabus, slides, and course information: www.cs.washington.edu/education/courses/590rr/03au/

Undergraduate course on Data Structures and Algorithm Analysis (CSE 326), UW, Winter 2003. Textbook: Data Structures and Algorithm Analysis in Java/C++ by Mark Weiss. Syllabus, slides, and course information: www.cs.washington.edu/education/courses/326/03wi/

Graduate seminar on Neural Computation (CSE 590NC), UW, Autumn, Winter and Spring 2001-2003. Course information: www.cs.washington.edu/education/courses/590nc/

Undergraduate and graduate independent study (CSE 498, MATH 498, and CSE 600), 2001-present.

Undergraduate course on Data Structures and Algorithm Analysis (CSE 373), UW, Spring 2001. Textbook: Data Structures and Algorithm Analysis in C by Mark Weiss. Syllabus, slides, and course information: www.cs.washington.edu/education/courses/373/01sp/

Professional Masters Program course on Alternative Computing Paradigms (CSE 599), UW, Winter 2001. Textbook: Feynman Lectures on Computation by Richard Feynman. Syllabus, slides, and course information: www.cs.washington.edu/education/courses/599/01wi/

Delivered lectures for an undergraduate course on Computational Neurobiology (BIPN 146) at University of California, San Diego, 1999. Professor: T. Sejnowski. Textbook: Biophysics of Computation by Christof Koch.

Teaching Assistant, Department of Computer Science, University of Rochester, Spring 1993 and 1994. Courses: 1. Theory of Computation 2. Design and Analysis of Algorithms.

Teaching Assistant, Mathematics Department, Angelo State University, 1989-1992. Undergraduate courses on calculus and analytical geometry.

Teaching Assistant, Physics Department, Angelo State University, 1989-1990. Undergraduate courses on fundamentals of physics.

**GRADUATE
MENTORING
(CURRENT)**

Aaron Shon, graduate student, CSE. Research Topic: Probabilistic Imitation Learning. Completed Qualifying and Generals exams. Expected Graduation Date: June, 2006.

David Grimes, graduate student, CSE. Research Topic: Probabilistic Vision and Learning. Completed Qualifying and Generals exams. Expected Graduation Date: June, 2006.

Pradeep Shenoy, graduate student, CSE. Research Topic: Brain-Computer Interfaces. Completed Qualifying exam. Expected Date for Generals Exam: Spring, 2005.

Deepak Verma, graduate student, CSE. Research Topic: Planning and Policy Learning using Graphical Models. Completed Qualifying exam. Expected Date for Generals Exam: Autumn, 2005.

Xu Miao, graduate student, CSE. Research Topic: Learning Lie Groups for Invariant Pattern Recognition. Expected Date for Qualifying Exam: Spring, 2005.

Kai Miller, graduate student, Medical Scientist Training Program, UW. Research Topic: Computational Neuroscience and Brain-Computer Interfaces. Expected Graduation Date: Spring, 2007.

Rawichote Chalodhorn, visiting graduate student, Osaka University, Japan. Research Topic: Learning in Humanoid Robots (Primary Advisor: Minoru Asada).

Alex Dieudonne, graduate student, Biology and UW Neurobiology and Behavior Program (Primary Advisor: Tom Daniel).

**GRADUATE
MENTORING
(PAST)**

Sangyun Han, graduate student, CSE. Research Topic: Automatic Tactilization of Graphics for the Blind (Primary Advisor: Richard Ladner).

Pat Tressel, graduate student, CSE. Research Topic: Computational Neuroscience. Now working at UW Medical School.

Tim Hanks, Brian Lundstrom, and Jeff Longnion, graduate students (in lab rotation), UW Neurobiology and Behavior Program and UW Medical Scientist Training Program.

**UNDERGRAD
MENTORING
(CURRENT)**

Gabriel Maganis and Danny Rashid, undergraduate students, CSE. Research Topic: Humanoid Robotics.

Nathan Evans, Ian Ma, and Christian Bell, undergraduate students, CSE. Research Topic: Brain-Computer Interfaces.

Yanni Wu, undergraduate student and Boeing Scholar, CSE. Research Topic: Vision for Humanoid Robotics.

**UNDERGRAD
MENTORING
(PAST)**

Matt Hoffman, undergraduate student and Mary Gates scholar, CSE. Research Topic: Gaze Following by a Robotic Head. Presently a graduate student at UBC.

Chris Baker, undergraduate student and Mary Gates scholar, Early Identification Program, CSE, 2002-2004. Research Topic: Neural Computation with Dynamic Synapses. Presently a graduate student at MIT.

Beau Crawford, undergraduate student, CSE. Honorable mention in the nation-wide CRA Outstanding Undergraduate Student competition, 2003-2005. Research Topic: Brain-Computer Interfaces.

Kohen Chia, Brian Chang, Ikroop Dhillon, Tushar Jain, Samuel Kim, Lloyd Parlee, and Ie Ming Tjam, undergraduate students, CSE, 2002-2005. Research Topic: Brain-Computer Interfaces.

Shengli Zhou, undergraduate student, CSE, 2003-2004. Research Topic: Probabilistic Color Indexing.

Yow Han, undergraduate student, CSE, 2003-2004. Research Topic: Face Detection in a Humanoid Robot.

Abhinav Jain, undergraduate student, CSE, 2003-2004. Research Topic: Face Detection. Presently a graduate student at Purdue.

Tulika Kumar, undergraduate student and Mary Gates scholar, CSE, 2002-2003. Research Topic: Reinforcement Learning in a Robotic Head. Currently at Action Engine.

Alice Chen-Chun Lin, undergraduate student and Mary Gates scholar, CSE, 2003. Research Topic: Visual Learning in a Robotic Head.

Marshella Tjandra, undergraduate student, Applied and Computational Mathematical Sciences, UW, 2002. Research Topic: Vision and Learning.

Thomas Carlson, Mary Gates Scholar, CSE, 2002. Research Topic: Imitation Learning.

**DEPARTMENT
SERVICE**

CSE Space Management Committee, 2004-present (with Prof. Paul Beame, Erik Lundberg, Tracy Bartholomew, Chris Cunningham).

CSE Course Scheduling Committee, 2004 (with Prof. Richard Anderson).

CSE Department Diversity Committee, 2001-2004. Participated in the formulation of a new plan for enhancing recruitment and retention of women and minorities in the CSE department.

Committee Member: Generals committee for CSE students Seth Bridges, Miguel

Figuroa, David Hsu, Amol Prakash, Kambiz Rahimi, Zasha Weinberg, and Ken Yasuhara. Final exam committee for CSE students Zasha Weinberg, David Hsu, and Yung-Yu Chuang.

UNIVERSITY SERVICE

Faculty Field Tour, 2002. Participated in a five-day faculty bus tour around the state of Washington with President Richard L. McCormick to further relations of UW with the residents of Washington state.

Mentor, UW Early Identification Program (EIP), 2002. Goal: To encourage and assist UW undergraduate students from underrepresented, educationally, and economically disadvantaged groups to enter graduate school. Advisees: Chris Baker and Ie Ming Tjam.

Graduate School Representative (GSR), 2001-present: Niranjan Balu, Lara Touryan and Kristopher Kubow, UW Bioengineering department.

Thesis Committee Member, 2004-present: Alex Dieudonne, Zoology Department.

Lab Rotation Advisor, 2001-present: Kai Miller, Alex Dieudonne, Tim Hanks, Brian Lundstrom, and Jeff Longnion, UW Neurobiology and Behavior Program and UW Medical Scientist Training Program.

CROSS-CAMPUS PARTNERSHIPS

Collaborative research on *Imitation Learning in Infants and Robots* with Andrew Meltzoff (co-director, UW Institute for Learning and Brain Sciences).

Collaborative research on *Brain-Computer Interfaces using ECoG and Neural Activity* with Jeff Ojemann (neurosurgeon, UW Medical Center and Harborview Hospital) and Eb Fetz (UW Department of Physiology and Biophysics).

Collaborative research on *Tactilization of Graphics for the Blind* with Richard Ladner (CSE), Melody Ivory-Ndiaye (UW Information School), and Sheryl Burgstahler (director, UW DO-IT program).

PROFESSIONAL ACTIVITIES

Program Committees: Uncertainty in AI (UAI), 2005; Third International Conference on Development and Learning (ICDL), 2004; American Association for Artificial Intelligence (AAAI) annual conference, 2004; Neural Information Processing Systems (NIPS), 2003; Computer Vision and Pattern Recognition (CVPR), 2000; American Association for Artificial Intelligence (AAAI) annual conference, 1997.

Conference Session Chair: Society for Neuroscience Annual Meeting, San Diego, October 27, 2004 (chair for session on “Visual Cortex: States and Networks”); Neural Information Processing Systems (NIPS), 2003 (chair for two oral sessions on Computational Neuroscience and Neural Engineering, December 9 and 10).

Organizing Committee: Neural Information Processing Systems (NIPS), 2002.

Organizer: Okinawa Computational Neuroscience Course, November 9-19, 2004 (with K. Doya, S. Ishii, and A. Pouget); Workshop on “Statistical Theories of Cortical Function” at Breckenridge, Colorado, December 4, 1998 (with B. Olshausen and M. Lewicki).

Editorial Board: Machine Learning Journal and Autonomous Robots Journal (Joint Special Issue on Learning in Autonomous Robots, 1998); Neural Computation (Communicating Reviewer).

Reviewer (Journals): Nature Neuroscience, Neural Computation, Neural Networks, Network: Computation in Neural Systems, Journal of Neuroscience, Biological Cybernetics, Journal of Cognitive Neuroscience, Psychological Science, Cognitive Science, Visual Cognition, Neuropharmacology, IEEE Transactions on Robotics and Automation, IEEE Pattern Analysis and Machine Intelligence, International Journal of Computer Vision, Computer Vision and Image Understanding, Human Computer Interaction, Physical Review Letters, Information Processing Letters, Theoretical Computer Science, Videre: A Journal of Computer Vision Research.

Reviewer (Conferences): Neural Information Processing Systems (NIPS) 1997-2004, American Association for Artificial Intelligence (AAAI), 2004, Computer Vision and Pattern Recognition (CVPR) 1997, Int. Conf. on Computer Vision (ICCV) 1995.

Reviewer (Funding Agencies): National Science Foundation (NSF) Emerging Technologies (EMT) review panel 2004, NSF CAREER award review panel 2002, NSF postdoctoral fellowship review 2002, NIMH grant review 2003.

Organizations: Association of Computing Machinery (ACM), Society for Neuroscience, IEEE (current). Past: New York Academy of Sciences, ACM Special Interest Group on Algorithms and Computation Theory and ACM Special Interest Group on Artificial Intelligence.

RESEARCH INTERESTS

Computational neuroscience, brain-computer interfaces, and humanoid robotics.

PUBLICATIONS

Books

1. *Probabilistic Models of the Brain: Perception and Neural Function*, Rajesh P. N. Rao, Bruno A. Olshausen and Michael S. Lewicki (Eds.), Cambridge, MA: MIT Press, 2002.
2. *The Bayesian Brain: Probabilistic Approaches to Neural Coding*, Kenji Doya, Shin Ishii, Rajesh P. N. Rao, and Alexandre Pouget (Eds.), Cambridge, MA: MIT Press, 2005 (in preparation).

Book Reviews

3. "Awakening a sleeping cat: A review of *Information Theory and the Brain* edited by R. Baddeley, P. Hancock, and P. Földiák," Rajesh P. N. Rao, *Neural Networks*, Vol. 15(7), pp. 927-929, 2002.
4. "Learning to maximize rewards: A review of Sutton and Barto's *Reinforcement Learning: An Introduction*," Rajesh P. N. Rao, *Neural Networks*, Vol. 13(1), pp. 135-137, 2000.

Invited Reviews

5. "Probabilistic Models of Attention based on Iconic Representations and Predictive Coding," Rajesh P. N. Rao and Dana H. Ballard, *Neurobiology of Attention*, Elsevier, 2005.
6. "Receptive Field," Rajesh P. N. Rao, *Encyclopedia of the Human Brain*, Academic Press, San Diego, CA, 2002.
7. "Models of Attention," Rajesh P. N. Rao, *Encyclopedia of Cognitive Science*, Macmillan Publishers, UK, 2002.

Research Articles: Computational Neuroscience

8. Pradeep Shenoy, Matthias Krauledat, Benjamin Blankertz, Rajesh P. N. Rao and Klaus-Robert Mueller. "Towards adaptive classification for BCI" *The Journal of Neural Engineering*, 2006 (to appear).
9. E. C. Leuthardt, K. J. Miller, G. Schalk, R. P. N. Rao, and J. G. Ojemann. "Electrocorticography-based Brain Computer interface - the Seattle experience" *IEEE Trans Biomed Eng*, 2006 (to appear).
10. Matt Hoffman, David B. Grimes, Aaron P. Shon, and Rajesh P. N. Rao. "A Probabilistic Model of Gaze Imitation and Shared Attention," *Neural Networks*, 2006 (to appear).
11. Deepak Verma and Rajesh P. N. Rao. "Goal-Based Imitation as Probabilistic Inference over Graphical Models" *Advances in Neural Information Processing Systems 18*, Cambridge, MA: MIT Press, 2006 (to appear).
12. Rajesh P. N. Rao. "Bayesian Inference and Attentional Modulation in the Visual Cortex" *Neuroreport*, Vol. 16(16), 1843-1848, 2005.
13. K. J. Miller, G. Schalk, J. W. Miller, R. P. N. Rao, E. C. Leuthardt, J. M. Zacks, and J. G. Ojemann. "Selective attention effects associated with very high frequency changes in human primary visual cortex" *Soc Neurosci Abs*, 2005.
14. Rajesh P. N. Rao. "Hierarchical Bayesian Inference in Networks of Spiking Neurons," *Advances in Neural Information Processing Systems 17*, Cambridge, MA: MIT Press, pp. 1113-1120, 2005.

15. Pradeep Shenoy and Rajesh P. N. Rao. "Dynamic Bayesian Networks for Brain-Computer Interfaces," *Advances in Neural Information Processing Systems 17*, Cambridge, MA: MIT Press, pp. 1265-1272, 2005.
16. David B. Grimes and Rajesh P. N. Rao. "Sparse Bilinear Models for Invariant Vision," *Neural Computation*, Vol. 17(1), pp. 47-73, 2005.
17. Rajesh P. N. Rao, Aaron P. Shon, and Andrew N. Meltzoff. "A Bayesian Model of Imitation in Infants and Robots," in *Imitation and Social Learning in Robots, Humans and Animals: Behavioural, Social and Communicative Dimensions*, K. Dautenhahn and C. L. Nehaniv (eds.), Cambridge University Press, UK, 2005 (to appear).
18. Beau Crawford, Kai Miller, Pradeep Shenoy and Rajesh P. N. Rao, "Real-Time Classification of Electromyographic Signals for Robotic Control," *Proceedings of AAAI-05*, 2005.
19. Kai Miller, Gerwin Schalk, Rajesh P. N. Rao and Jeffrey Ojemann. "Robust Classification of Electrocorticographic Signals for BCI" (submitted), 2005.
20. Pradeep Shenoy, Matthias Krauledat, Benjamin Blankertz, Rajesh Rao and Klaus-Robert Mueller. "Online Adaptation for CSP-based BCI Systems" (submitted), 2005.
21. Pradeep Shenoy and Rajesh P. N. Rao. "Bayesian Integration of Task Context for Emerging User Interface Technologies" (submitted), 2005.
22. Rajesh P. N. Rao. "Bayesian Computation in Recurrent Neural Circuits," *Neural Computation*, Vol. 16(1), pp. 1-38, 2004.
23. Aaron P. Shon, Rajesh P. N. Rao, and Terrence J. Sejnowski. "Motion Detection and Prediction through Spike-Timing Dependent Plasticity," *Network: Computation in Neural Systems*, Vol. 15, pp. 179-198, 2004.
24. Aaron P. Shon and Rajesh P. N. Rao. "Implementing Belief Propagation in Neural Circuits," *Proc. of the Computational Neuroscience (CNS) Annual Meeting*, 2004 .
25. Chris L. Baker, Aaron P. Shon, and Rajesh P. N. Rao. "Learning Temporal Clusters with Synaptic Facilitation and Lateral Inhibition," *Proc. of the Computational Neuroscience (CNS) Annual Meeting*, 2004.
26. Aaron P. Shon, David B. Grimes, Chris L. Baker, and Rajesh P. N. Rao. "A Probabilistic Framework for Model-Based Imitation Learning," *Proc. of the 26th Annual Meeting of the Cognitive Science Society*, 2004.
27. Rajesh P. N. Rao and Terrence J. Sejnowski. "Self-Organizing Neural Systems based on Predictive Learning" (Invited Paper) *Philosophical Transactions of the Royal Society: Mathematical, Physical & Engineering Sciences* (Proceedings of the Nobel Symposium on Self-Organization), Vol. 361(1807), 2003.

28. Rajesh P. N. Rao and Andrew N. Meltzoff. "Imitation Learning in Infants and Robots: Towards Probabilistic Computational Models" (Invited Paper) *Proceedings of Artificial Intelligence and Simulation of Behavior (AISB) 2003: Cognition in Machines and Animals*, UK, 2003.
29. David B. Grimes and Rajesh P. N. Rao. "A Bilinear Model for Sparse Coding" *Advances in Neural Information Processing Systems 15*, Cambridge, MA: MIT Press, 2003.
30. Aaron P. Shon and Rajesh P. N. Rao. "Learning Temporal Patterns by Redistribution of Synaptic Efficacy" *Neurocomputing*, Vol. 52-54, pp. 13-18, 2003.
31. Rajesh P. N. Rao and Terrence J. Sejnowski. "Complex Cell-Like Direction Selectivity through Spike-Timing Dependent Plasticity" *IETE Journal of Research*, Vol. 49(2), 2003.
32. Rajesh P. N. Rao, Gregory J. Zelinsky, Mary M. Hayhoe, and Dana H. Ballard. "Eye Movements in Iconic Visual Search" *Vision Research*, Vol. 42(11), pp. 1447-1463, 2002.
33. Rajesh P. N. Rao and Terrence J. Sejnowski. "Spike Timing Dependent Hebbian Plasticity as Temporal Difference Learning" *Neural Computation*, Vol. 13(10), pp. 2221-2237, 2001. Featured in a **News and Views** article by Peter Dayan in *Trends in Cognitive Science*, Vol. 6(3), pp. 105-106, 2002.
34. Rajesh P. N. Rao and Terrence J. Sejnowski. "Predictive Coding, Cortical Feedback, and Spike-Timing Dependent Plasticity" in *Probabilistic Models of the Brain: Perception and Neural Function*, R. P. N. Rao, B. A. Olshausen and M. S. Lewicki (Eds.), Cambridge, MA: MIT Press, pp. 297-315, 2002.
35. Dana H. Ballard, Zuohua Zhang, and Rajesh P. N. Rao. "Distributed Synchrony: A Probabilistic Model of Neural Signaling" in *Probabilistic Models of the Brain: Perception and Neural Function*, R. P. N. Rao, B. A. Olshausen and M. S. Lewicki (Eds.), Cambridge, MA: MIT Press, pp. 273-283, 2002.
36. Rajesh P. N. Rao, David Eagleman, and Terrence J. Sejnowski. "Optimal Smoothing in Visual Motion Perception" *Neural Computation*, Vol. 13(6), pp. 1243-1253, 2001.
37. J. M. Fellous, A. R. Houweling, R. H. Modi, R. P. N. Rao, P. H. E. Tiesinga, and T. J. Sejnowski. "The Frequency Dependence of Spike Timing Reliability in Cortical Pyramidal Cells and Interneurons" *J. Neurophysiology*, Vol. 85(4), pp. 1782-1787, 2001.
38. Rajesh P. N. Rao and Terrence J. Sejnowski. "Predictive Learning of Temporal Sequences in Recurrent Neocortical Circuits" *Novartis Foundation 2001 Symposium on Complexity in Biological Info. Processing*, Vol. 239, pp. 208-229 (discussion: 229-240), 2001.
39. Chris Diorio and Rajesh P. N. Rao, "Neural Circuits in Silicon" *Nature*, Vol. 405, pp. 891-892, 2000.

40. Rajesh P. N. Rao and Terrence J. Sejnowski. "Predictive Sequence Learning in Recurrent Neocortical Circuits" *Advances in Neural Information Processing Systems 12*, Cambridge, MA: MIT Press, pp. 164-170, 2000.
41. Dana H. Ballard, Rajesh P. N. Rao, and Zuohua Zhang, "A Single-Spike Model of Predictive Coding" *Neurocomputing*, Vol. 32-33, pp. 17-23, 2000.
42. Rajesh P. N. Rao and Dana H. Ballard. "Predictive Coding in the Visual Cortex: A Functional Interpretation of Some Extra-Classical Receptive Field Effects" *Nature Neuroscience*, Vol. 2(1), pp. 79-87, 1999. Featured in a **News and Views** article by Christof Koch and Tomaso Poggio in the same issue.
43. Rajesh P. N. Rao. "An Optimal Estimation Approach to Visual Perception and Learning" *Vision Research*, Vol. 39(11), pp. 1963-1989, 1999.
44. Rajesh P. N. Rao and Daniel L. Ruderman. "Learning Lie Groups for Invariant Visual Perception" M. S. Kearns, S. A. Solla and D. Cohn (Eds.), *Advances in Neural Information Processing Systems 11*, Cambridge, MA: MIT Press, pp. 810-816, 1999.
45. Rajesh P. N. Rao and Dana H. Ballard. "Development of Localized Oriented Receptive Fields by Learning a Translation-Invariant Code for Natural Images" *Network: Computation in Neural Systems*, Vol. 9(2), pp. 219-234, 1998.
46. Rajesh P. N. Rao. "Correlates of Attention in a Model of Dynamic Visual Recognition" M. I. Jordan, M. J. Kearns and S. A. Solla (Eds.), *Advances in Neural Information Processing Systems 10*, Cambridge, MA: MIT Press, pp. 80-86, 1998.
47. Dana H. Ballard, Garbis Salgian, Rajesh P. N. Rao and R. Andrew McCallum. "On the role of time in brain computation" L. R. Harris and M. Jenkin (Eds.), *Vision and Action*, Cambridge, UK: Cambridge University Press, pp. 82-119, 1998.
48. Rajesh P. N. Rao and Dana H. Ballard. "Dynamic Model of Visual Recognition Predicts Neural Response Properties in the Visual Cortex" *Neural Computation*, Vol. 9, pp. 721-763, 1997.
49. Rajesh P. N. Rao and Dana H. Ballard. "Efficient Encoding of Natural Time Varying Images Produces Oriented Space-Time Receptive Fields" Technical Report 97.4, National Resource Laboratory for the Study of Brain and Behavior, University of Rochester, August 1997.
50. Rajesh P. N. Rao and Dana H. Ballard. "Cortico-Cortical Dynamics and Learning during Visual Recognition: A Computational Model" J. M. Bower (editor), *Computational Neuroscience: Trends in Research 1997*, New York, NY: Plenum Press, pp. 787-793, 1997.
51. Rajesh P. N. Rao and Dana H. Ballard. "A Computational Model of Spatial Representations That Explains Object-Centered Neglect in Parietal Patients" J. M.

- Bower (editor), *Computational Neuroscience: Trends in Research 1997*, New York, NY: Plenum Press, pp. 779-785, 1997.
52. Dana H. Ballard, Mary M. Hayhoe, Polly K. Pook, and Rajesh P.N. Rao. "De-ictic Codes for the Embodiment of Cognition" *Behavioral and Brain Sciences*, Vol. 20(4), pp. 723-767, 1997.
 53. Rajesh P. N. Rao, Gregory J. Zelinsky, Mary M. Hayhoe, and Dana H. Ballard. "Modeling Saccadic Targeting in Visual Search" D. Touretzky, M. Mozer and M. Hasselmo (Eds.), *Advances in Neural Information Processing Systems 8*, Cambridge, MA: MIT Press, pp. 830-836, 1996.
 54. Rajesh P. N. Rao and Dana H. Ballard. "Learning Saccadic Eye Movements using Multiscale Spatial Filters" G. Tesauro, D.S. Touretzky and T.K. Leen (Eds.), *Advances in Neural Information Processing Systems 7*, Cambridge, MA: MIT Press, pp. 893-900, 1995.
 55. Dana H. Ballard and Rajesh P. N. Rao. "A Computational Model of Human Vision Based on Visual Routines" (Invited Paper) Proc. of the DAGM (German Working Group in Pattern Recognition) Symposium, G. Sagerer, S. Posch, and F. Kummert (Eds.), Berlin: Springer-Verlag, 1995.

Research Articles: Robotics and Machine Learning

56. Aaron P. Shon, Keith Grochow, Aaron Hertzmann and Rajesh P. N. Rao, "Learning Shared Latent Structure for Image Synthesis and Robotic Imitation" *Advances in Neural Information Processing Systems 18*, Cambridge, MA: MIT Press, 2006 (to appear).
57. Aaron P. Shon, Keith Grochow, Aaron Hertzmann and Rajesh P. N. Rao, "Robotic Imitation from Human Motion Capture using Gaussian Processes" *Proceedings of the 2005 Humanoid Robotics conference*, 2005 (to appear).
58. Rawichote Chalodhorn, David B. Grimes, Gabriel Maganis, and Rajesh P. N. Rao, "Learning Dynamic Humanoid Motion using Predictive Control in Low Dimensional Subspaces" *Proceedings of the 2005 Humanoid Robotics conference*, 2005 (to appear).
59. David B. Grimes and Rajesh P. N. Rao. "Nonlinear Feedback Control using Nonparametric Belief Propagation" (submitted), 2005.
60. Deepak Verma and Rajesh P. N. Rao. "Graphical Models for Action Selection in Dynamic Partially Observable Environments" (submitted), 2005. Also, Technical Report 2005-02-01, Dept. of Computer Science and Engineering, University of Washington, 2005.
61. Aaron P. Shon, Matt Hoffman, Shengli Zhou, Chris L. Baker, David B. Grimes, and Rajesh P. N. Rao. "Probabilistic Gaze Imitation in a Robotic Head," *Proc. of the International Conference on Robotics and Automation (ICRA)*, 2005.

62. Rajesh P. N. Rao and Olac Fuentes. "Hierarchical Learning of Navigational Behaviors in an Autonomous Robot using a Predictive Sparse Distributed Memory" *Autonomous Robots*, Vol. 5, pp. 297-316, 1998 and *Machine Learning*, Vol. 31, pp. 87-113, 1998.
63. Rajesh P. N. Rao and Olac Fuentes. "Learning Navigational Behaviors using a Predictive Sparse Distributed Memory" *From Animals to Animats: Proc. of the Fourth Int. Conf. on Simulation of Adaptive Behavior*, pp. 382-390, 1996.
64. Olac Fuentes, Rajesh P. N. Rao, and Michael Van Wie. "Hierarchical Learning of Reactive Behaviors in an Autonomous Mobile Robot" *Proc. of IEEE International Conference on Systems, Man and Cybernetics*, 1995.
65. Rajesh P. N. Rao and Olac Fuentes. "Perceptual Homing by an Autonomous Mobile Robot using Sparse Self-Organizing Sensory-Motor Maps" *Proc. of World Congress on Neural Networks*, pp. II380-II383, 1995.

Research Articles: Computer Vision

66. David B. Grimes, Aaron P. Shon, and Rajesh P. N. Rao. "Probabilistic Bilinear Models for Appearance-Based Vision" *Proc. of the International Conference on Computer Vision (ICCV)*, 2003.
67. Rajesh P. N. Rao. "Dynamic Appearance-Based Recognition" *Proc. of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'97)*, pp. 540-546, 1997.
68. Rajesh P. N. Rao. "A Kalman Filter That Learns Robust Models of Dynamic Phenomena" *Proceedings of the 1997 Image Understanding Workshop*, New Orleans, LA, 1997.
69. Rajesh P. N. Rao and Dana H. Ballard. "An Active Vision Architecture based on Iconic Representations" *Artificial Intelligence*, Vol. 78, pp. 461-505, 1995.
70. Rajesh P. N. Rao and Dana H. Ballard. "Natural Basis Functions and Topographic Memory for Face Recognition" *Proc. of the International Joint Conference on Artificial Intelligence (IJCAI)*, pp. 10-17, 1995.
71. Rajesh P. N. Rao and Dana H. Ballard. "Object Indexing using an Iconic Sparse Distributed Memory" *Proc. of the International Conference on Computer Vision (ICCV)*, pp. 24-31, 1995.
72. Rajesh P. N. Rao. "Top-Down Gaze Targeting for Space-Variant Active Vision." *Proc. of the ARPA Image Understanding Workshop*, Monterey, CA, pp. 1049-1058, November 1994.
73. Rajesh P. N. Rao and Dana H. Ballard. "A Multiscale Filterbank Approach to Camera Movement Control in Active Vision Systems." *Proc. of 1994 SPIE Conference on Intelligent Robots and Computer Vision XIII : 3D Vision, Product Inspection, and Active Vision*, Vol. 2354, pp. 105-116, 1994.

74. Dana H. Ballard, Rajesh P.N. Rao, and Garbis Salgian. "Multiscale Spatial Filters for Visual Tasks and Object Recognition." (Invited Paper) *Proc. of the Second International Workshop on Visual Form*, Capri, Italy, May, 1994.
75. Dana H. Ballard, and Rajesh P.N. Rao. "Seeing behind Occlusions." *Proc. of the Third European Conference on Computer Vision (ECCV)*, Stockholm, Sweden, May 1994, pp. 274-285.

Research Articles: Theoretical Computer Science

76. Rajesh P. N. Rao. "A Note on P-Selectivity and Closeness" *Information Processing Letters*, Vol. 54, pp. 179-185, 1995.
77. Rajesh P. N. Rao, Jörg Rothe and Osamu Watanabe. "Upward Separation for FewP and Related Classes" *Information Processing Letters*, Vol. 52, No. 4, pp. 175-180, 1994.

Research Articles: Psychophysics

78. Gregory J. Zelinsky, Rajesh P. N. Rao, Mary M. Hayhoe, and Dana H. Ballard. "Eye Movements Reveal the Spatiotemporal Dynamics of Visual Search" *Psychological Science*, Vol. 8(6), pp. 448-453, 1997.
79. Gregory J. Zelinsky, Rajesh P. N. Rao, Mary M. Hayhoe, and Dana H. Ballard. "Adding Resolution to an Old Problem: Eye Movements as a Measure of Visual Search" G. Cottrell (editor), *Proc. of the 18th Annual Conference of the Cognitive Science Society*, June 12-15, La Jolla, CA, pp. 57-58, 1996.

Popular Media

1. Quoted in a story on building neural circuits in silicon. *New York Times*, page D12, June 29, 2000.
2. Rajesh P. N. Rao. "Building Computers That See, Adapt and Learn" Translated article (in Kannada) appeared in *Udayavani Kannada Daily* (India), July 21, 1996.
3. Quoted in a story describing our group's mobile robot research (see above). *Rochester Democrat and Chronicle* (Daily), page 8B, December 22, 1994.
4. Brief television interviews on mobile robot research. Rochester News Channel 13 and Rochester Independent News, December 1994.

INVITED TALKS

1. *Probabilistic Models of Brain Function and their Applications to Brain-Computer Interfaces*. Allen Institute for Brain Science, Seattle, December, 2005.

2. *Generative Models for Visual Invariance*. Workshop on Invariant Representations in Vision, Computational and Systems Neuroscience (CoSyNe) workshops, Snowbird, March, 2005.
3. *Visual Attention as Hierarchical Bayesian Inference*. Workshop on Bayesian Approaches to Sensory and Motor Processing, Computational and Systems Neuroscience (CoSyNe) workshops, Snowbird, March, 2005.
4. *A Bayesian Model of Sensorimotor Learning and Imitation in Infants and Robots*. IPAM Workshop on Probabilistic Models of Cognition, UCLA, CA, January 27, 2005.
5. *Probabilistic Models of Cortical Computation*. Okinawa Computational Neuroscience Course, Japan, November 16, 2004.
6. *Probabilistic Models of Cortical Computation and Communication*. Banbury Meeting on Communication in Brain Systems, Cold Spring Harbor Laboratory, NY, May 18, 2004.
7. *Bayesian Computation in Neural Circuits*. Computation and Neural Systems Colloquium, Caltech, Pasadena, CA, April 12, 2004.
8. *Probabilistic Computation in Neural Circuits*. MSRI Workshop on Mathematical Neuroscience, UC Berkeley, CA, March 18, 2004.
9. *Bayesian Computation in Neural Circuits*. Redwood Neuroscience Institute (RNI), Menlo Park, CA, March 16, 2004.
10. *STDP and Predictive Coding*. The Monte-Verita Workshop on Spike-Timing Dependent Plasticity, Ascona, Switzerland, March 3, 2004.
11. *Probabilistic Computation in Neural Systems*. Packard Fellows Annual Meeting, Vancouver, BC, September 5, 2003.
12. *Probabilistic Computation in Recurrent Neural Circuits*. Sloan-Swartz Annual Meeting on Theoretical Neurobiology, Del Mar, CA, July 27, 2003.
13. *Imitation Learning in Infants and Robots: Towards Probabilistic Computational Models*. Keynote talk, Artificial Intelligence and Simulation of Behavior (AISB) Convention 2003: Cognition in Machines and Animals, UK, April 7, 2003.
14. *Bayesian Computation in Recurrent Cortical Circuits*. Neural Information and Coding Workshop, Snowbird, Utah, March 2, 2003.
15. *Probabilistic Computation in Recurrent Cortical Circuits*. Workshop on Neural Coding, Mathematical Biosciences Institute, Ohio State University, February 12, 2003.
16. *Bilinear Models and Lie Groups: Two Approaches to Learning Invariance using Generative Models*. NIPS workshop on Learning Invariant Representations, Whistler B.C., Canada, December 13, 2002.

17. *Bayesian Computation in Recurrent Cortical Circuits*. Workshop on System Level Modeling, Mathematical Biosciences Institute, Ohio State University, November 22, 2002.
18. *Bayesian Inference in Recurrent Cortical Circuits*. National Center for the Biological Sciences, Bangalore, India, August, 2002.
19. *Bayesian Inference in Recurrent Cortical Circuits*. Telluride Workshop on Neuromorphic Engineering, Telluride, Colorado, July 11, 2002.
20. *Spike-Timing Dependent Plasticity and Predictive Coding in the Visual Cortex*. Activity-Dependent Synaptic Plasticity Workshop, Whistler B.C., Canada, December 8, 2002.
21. *Computational Models of the Visual Cortex: From Neurons to Perception*. Department of Bioengineering, University of Utah, Salt Lake City, December 15, 2000.
22. *Predictive Coding in Recurrent Neocortical Circuits*. Neuroinformatics Summer School, Japanese Neural Networks Society, Hayama, Japan, August 11, 2000.
23. *Spike Timing Dependent Plasticity and Sequence Learning in Recurrent Cortical Circuits*. Laboratory for Information Synthesis, Brain Research Institute, RIKEN, Japan, August 9, 2000.
24. *Spike Timing Dependent Plasticity and Motion Detection in Primary Visual Cortex*. Kawato Dynamic Brain Project, ATR, Japan, August 4, 2000.
25. *Modeling the Visual Cortex: From Neurons to Perception*. Biomedical Engineering Department, University of California, Irvine, May 4, 2000.
26. *The Predictive Coding Hypothesis of Cortical Function*. Neuroscience Department, Brown University, April 5, 2000.
27. *Dynamic Vision*. Department of Computer Science, University of Southern California, Los Angeles, March 23, 2000.
28. *From Endstopping to Attention: Insights from the Predictive Coding Hypothesis of Cortical Function*. Center for Neural Science, University of California, Davis, March 17, 2000.
29. *Neurally Inspired Algorithms for Machine Vision and Learning*. Department of Computer Science and Engineering, University of California, San Diego, March 6, 2000; University of Washington, Seattle, March 28, 2000.
30. *Attention as Robust Statistical Filtering*. Neural Mechanisms of Perceptual Selection in Visual and Prefrontal Cortex Workshop, Breckenridge, December, 1999.
31. *Optimal Smoothing in Visual Motion Perception: Evidence from the Flash Lag Effect*. Adaptive Computational Models and Short Time Perceptual Learning Workshop, Breckenridge, December, 1999.

32. *Predictive Learning of Direction Selectivity in Recurrent Neocortical Circuits*. Spike Timing and Synaptic Plasticity Workshop, Breckenridge, December, 1999.
33. *Prediction and Recurrent Excitation in the Neocortex*. Neural Information and Coding Workshop, Big Sky, Montana, March, 1999.
34. *The Predictive Coding Hypothesis of Cortical Function*. Center for Biological and Computational Learning, MIT, April 1998, Center for Visual Science Symposium, University of Rochester, June 1998 and Smith-Kettlewell Eye Institute, San Francisco, July 1998.
35. *Learning Spatiotemporal Generative Models*. Workshop on Computational Neuroscience and Generative Models, University of Toronto, February 1998.
36. *The Cerebral Cortex as a Predictor and Model Builder* (Postdoc Job Talk). The Salk Institute for Biological Studies, February 1997.
37. *The Visual Cortex as a Hierarchical Predictor*. Telluride Workshop on Neuro-morphic Engineering, July 1996.

CONFERENCE PRESENTA- TIONS

1. *Probabilistic Inference using Populations of Spiking Neurons* (poster). Computational and Systems Neuroscience (CoSyNe) conference, Salt Lake City, March, 2005.
2. *Hierarchical Bayesian Inference in Networks of Spiking Neurons* (poster). Neural Information Processing Systems (NIPS) conference, Vancouver, BC, December, 2004.
3. *Dynamic Bayesian Networks for Brain-Computer Interfaces* (poster), with Pradeep Shenoy. NIPS, Vancouver, BC, December, 2004.
4. *Hierarchical Bayesian Inference in Cortical Networks of Integrate-and-Fire Neurons* (talk). Society for Neuroscience Annual Meeting, October 27, 2004.
5. *Implementing Belief Propagation in Neural Circuits* (poster), with Aaron P. Shon. Computational Neuroscience (CNS) Annual Meeting, 2004.
6. *Learning Temporal Clusters with Synaptic Facilitation and Lateral Inhibition* (poster), with Chris L. Baker and Aaron P. Shon. Computational Neuroscience (CNS) Annual Meeting, 2004.
7. *Bayesian Imitation Learning in a Robotic Head* (demo), with Aaron P. Shon, Chris L. Baker, and David B. Grimes. NIPS 2003, Vancouver, BC, December, 2003.
8. *Probabilistic Bilinear Models for Appearance-Based Vision* (poster), with David Grimes and Aaron P. Shon. ICCV 2003, Nice, France, October, 2003.
9. *A Bilinear Model for Sparse Coding* (poster), with David B. Grimes. NIPS, Vancouver, BC, December, 2002.

10. *Predictive Sequence Learning in Recurrent Neocortical Circuits* (Spotlight). NIPS, Vancouver, BC, December, 1999.
11. *Direction Selectivity from Predictive Sequence Learning in Recurrent Neocortical Circuits*. Society for Neuroscience Annual Meeting (1999), 6th Joint Symposium on Neural Computation (1999).
12. *The Visual Cortex as a Hierarchical Predictor*. Society for Neuroscience Annual Meeting, 1997.
13. *Dynamic Appearance-Based Recognition*. IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR), 1997. Best presentation award in “Object Recognition” session.
14. *Cortico-Cortical Dynamics and Learning during Visual Recognition: A Computational Model*. Computational Neuroscience (CNS) Annual Meeting, 1996.
15. *Modeling Saccadic Targeting in Visual Search*. Neural Information Processing Systems (NIPS) Annual Conference, 1995.
16. *Perceptual Homing by an Autonomous Mobile Robot using Sparse Self-Organizing Sensory-Motor Maps*. World Congress on Neural Networks (WCNN), 1995.
17. *Natural Basis Functions and Topographic Memory for Face Recognition*. International Joint Conference on Artificial Intelligence (IJCAI), 1995.
18. *Object Indexing using an Iconic Sparse Distributed Memory*. International Conference on Computer Vision (ICCV), 1995.
19. *Learning Saccadic Eye Movements using Multiscale Spatial Filters*. Neural Information Processing Systems (NIPS) Annual Conference, 1994.
20. *A Multiscale Filterbank Approach to Camera Movement Control in Active Vision Systems*. SPIE Conference on Intelligent Robots and Computer Vision, 1994.
21. *Seeing behind Occlusions*. Third European Conference on Computer Vision (ECCV), Stockholm, Sweden, 1994.

PERSONAL

Born in Madras, India, July 2, 1970.

**OTHER
INTERESTS**

Indian and Persian art, history, racquetball, squash, table tennis, badminton, yoga.