

**TUCKER BALCH
ASSOCIATE PROFESSOR
SCHOOL OF INTERACTIVE COMPUTING
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I. EARNED DEGREES

- Ph.D. Computer Science, Georgia Institute of Technology, 1998
- M.S. Computer Science, University of California, Davis, 1988
- B.S. Information and Computer Science, Georgia Institute of Technology, 1984

II. EMPLOYMENT HISTORY

- Associate Professor, College of Computing, Georgia Institute of Technology, 2006-Present
- Assistant Professor, College of Computing, Georgia Institute of Technology, 2001-2006
- Research Scientist, Robotics Institute, Carnegie Mellon University, 1998-2001
- Fighter Pilot, US Air Force, 1988-1996

III. HONORS AND AWARDS

- **Outstanding Service Award**, Georgia Institute of Technology, 2012
- **CAREER Award**, National Science Foundation, 2004
- **Class of 1969 Teaching Fellow**, Georgia Institute of Technology, 2002
- **NASA Technical Innovation Award** (with Larry Matthies), NASA JPL, 1997
- **First Place, Robot Competition**, American Association for Artificial Intelligence, 1997
- **Outstanding Graduate Research Assistant**, College of Computing, Georgia Institute of Technology, 1996
- **First Place, Robot Competition**, American Association for Artificial Intelligence, 1994
- **Top Gun Award**, 128th Fighter Squadron, USAF, 1992
- **National Defense Service Medal**, USAF, 1991
- **Top Gun Award**, 128th Fighter Squadron, USAF, 1991
- **Distinguished Graduate**, USAF Pilot Training, 1989
- **Top Instrument Pilot**, USAF Pilot Training, 1989

IV. RESEARCH, SCHOLARSHIP, AND CREATIVE ACTIVITIES

Note: * Indicates publications that resulted from work done at Georgia Tech after appointment as assistant professor. Student co-authors are listed in **boldface**.

A. PUBLISHED BOOKS, PARTS OF BOOKS, AND EDITED VOLUMES

A1. Books

1. **What Hedge Funds Do*, Romero, P., Balch, T., *in editorial review*, 2014

A2. Refereed Book Chapters

None

A3. Other Parts of Books

1. *The Sting Racing Team's Entry to the Urban Challenge, **M Powers**, D Wooden, M Egerstedt, H Christensen, T Balch, Experience from the DARPA Urban Challenge, 43-65

2. *Communication, Diversity and Learning: Cornerstones of Swarm Behavior, Balch, T., in *Swarm Robotics*, Sahin E., and Spears, W. (eds). Springer Verlag. 2005.
3. *Mission-Relevant Collaborative Observation and Localization, **Stroupe, A.**, Balch, T., in Schultz, A. and Parker, L. (eds) *Multi-Robot Systems: From Swarms to Intelligent Automata*, Kluwer, 2002.
4. *Taxonomies of Multi-Robot Task and Reward, Balch, T., in *Robot Teams: From Diversity to Polymorphism*, Balch, T. and Parker, L. (eds), AK Peters, 2002.
5. Intelligent Robots, Balch, T., *World Book 2001 Science Year*, World Book Encyclopedia, 2001.
6. Communication and Coordination in Reactive Robotic Teams, Arkin, R.C. and Balch, T., in *Coordination Theory and Collaboration Technology*, Olsen, G. (ed), 2001.
7. Introduction and Overview of RoboCup-99, Veloso, M., Kitano, H., Pagello, E., Kraetzschmar, G., Stone, P., Balch, T., Asada, M., Coradeschi, S., Karlsson, L. and Fujita, M., in *RoboCup-99: Robot Soccer World Cup III*, Veloso, Pagello, Kitano (eds), Springer-Verlag, 2000.
8. Cooperative Multiagent Robotic Systems, Arkin, R.C. and Balch, T., *AI-based Mobile Robots: Case Studies of Successful Robot Systems*, D. Kortenkamp, R.P. Bonasso, and R. Murphy (eds), MIT Press, 1998. published

A4. Edited Volumes

1. **Robot Teams: From Diversity to Polymorphism*, Balch, T. and Parker, L. (eds), AK Peters, 2002.
2. *RoboCup-2000: Robot Soccer World Cup IV*, Stone, P., Balch, T., Kraetzschmar, G. (eds), Springer-Verlag, 2001.

B. REFEREED PUBLICATIONS AND SUBMITTED ARTICLES

Note: * Indicates publications that resulted from work done at Georgia Tech after appointment as assistant professor. Student co-authors are listed in **boldface**.

B1. Published and Accepted Journal Articles

1. *AUV Behavior Recognition using Behavior Histograms, HMMs, and CRFs, **M. Novitzky, C. Pippin**, T.R. Collins, T.R. Balch, and M.E. West. *Journal ROBOTICA*, Cambridge University Press. Volume 32. Pages 291-304. 2014.
2. *The multi-iterative closest point tracker: An online algorithm for tracking multiple interacting targets, **A Feldman**, M Hybinette, T Balch, *Journal of Field Robotics (JFR)* 29 (2), 258-276, 2012
3. *Augmenting live broadcast sports with 3D tracking information, R Cavallaro, M Hybinette, M White, T Balch, *IEEE MultiMedia* 18 (4), 2012
4. *A generic framework for distributed multirobot cooperation, **S Sariel-Talay**, TR Balch, N Erdogan, *Journal of Intelligent & Robotic Systems* 63 (2), 323-358, 2011
5. *Learning outdoor mobile robot behaviors by example, **R Roberts, C Pippin**, T Balch, *Journal of Field Robotics (JFR)* 26 (2), 176-195, 2009
6. *Multiple traveling robot problem: A solution based on dynamic task selection and robust execution, **S Sariel-Talay**, TR Balch, N Erdogan, *IEEE/ASME Transactions on Mechatronics*, 14 (2), 198-206, 2009
7. Personalizing CS1 with robots, T Balch, et al, *IEEE Pervasive Computing*, 7(2):5-9, April-June 2008

8. *Physical path planning using a pervasive embedded network, **KJ O'Hara**, DB Walker, TR Balch, *IEEE Transactions on Robotics (TRO)*, 24 (3), 741-746, 2008
9. *Learning and inferring motion patterns using parametric segmental switching linear dynamic systems, **SM Oh**, JM Rehg, T Balch, F Dellaert, *International Journal of Computer Vision (IJCV)* 77 (1-3), 103-124, 2008
10. *A modular, hybrid system architecture for autonomous, urban driving, **D Wooden, M Powers**, M Egerstedt, H Christensen, T Balch, *Journal of Aerospace Computing, Information, and Communication* 4 (12), 1047-1058, 2007
11. *Learning from examples in unstructured, outdoor environments, **J Sun, T Mehta, D Wooden, M Powers**, J Rehg, T Balch, M Egerstedt, *Journal of Field Robotics (JFR)* 23 (11-12), 1019-1036, 2006
12. *How multirobot systems research will accelerate our understanding of social animal behavior, T Balch, F Dellaert, **A Feldman, A Guillory**, CL Isbell, **Z Khan**, SC Pratt, *Proceedings of the IEEE* 94 (7), 1445-1463, 2006
13. *MCMC data association and sparse factorization updating for real time multitarget tracking with merged and multiple measurements, **Z Khan**, T Balch, F Dellaert, *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, 2006
14. *MCMC-Based Particle Filtering for Tracking a Variable Number of Interacting Targets, **Khan, Z.**, Balch, T., and Dellaert, F., *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, 2005.
15. *Niche Selection in Foraging Tasks in Multi-Robot Teams Using Reinforcement Learning. **Ulam, P.** and Balch, T., *Adaptive Behavior* 12 (4). 2004.
16. *Using optimal foraging models to evaluate learned robotic foraging behavior, **P Ulam, T Balch**, *Adaptive Behavior* 12 (4). 2004.
17. *Representing honey bee behavior for recognition using human trainable models, **A Feldman**, T Balch, *Adaptive Behavior* 12 (3). 2004.
18. *A 3-d Visual Tracking System for the Study of Spatial Navigation and Memory in Rhesus Monkeys, **Z. Khan**, R. A. Herman, K. Wallen, and T. Balch, *Behavior Research Methods, Instruments & Computers*, 2004.
19. *Rhesus monkey spatial cognition: Sex differences and effects of prenatal androgen exposure, RA Herman, **Z Khan**, T Balch, K Wallen, *Hormones and Behavior* 46 (1), 2004
20. *A Human Trainable System for Automated Social Insect Behavior Recognition, **Feldman, A.**, and Balch, T., *Adaptive Behavior* 12 (4). 2004.
21. *Value-Based Action Selection for Observation with Robot Teams Using Probabilistic Techniques, **Stroupe, A.** and Balch, T., *Journal of Robotics and Autonomous Systems*. 2004. (also published at ICAR 2003 conference).
22. Hierarchic Social Entropy: An Information Theoretic Measure of Robot Team Diversity, Balch, T., *Autonomous Robots (AURO)*, July, 2000.
23. Behavior-Based Formation Control for Multiagent Robot Teams, Balch, T. and Arkin, R.C., *IEEE Transactions on Robotics and Automation (TRA)*, 1998
24. AuRA: Principles and Practice in Review, Arkin, R.C. and Balch, T., *Journal of Experimental and Theoretical Artificial Intelligence*, 9 175-189, 1997.
25. Communication in Reactive Multiagent Robotic Systems, Balch, T. and Arkin, R.C., *Autonomous Robots (AURO)*, 1(1): 27-52, 1995.

B2. Conference Presentation with Proceedings (Refereed)

1. *Assessing Learned Models of Fish Schooling Behavior, **Hrolenok, Brian**, and Tucker Balch. International Conference on Autonomous Agents and Multiagent Systems (AAMAS), 2014.
2. *Learning Schooling Behavior from Observation. **Hrolenok, Brian**, and Tucker Balch. *Advances in Artificial Life, ECAL*, vol. 12, pp. 686-691. 2013.
3. *Learning a projective mapping to locate animals in video using RFID, **P Huang, R Sawhney**, D Walker, K Wallen, A Bobick, S Qin, T Balch, *IEEE Intl Conf on Intelligent Robots and Systems (IROS)*, 2012
4. *Ant Hunt: Towards a Validated Model of Live Ant Hunting Behavior, **Yang, Yu-Ting, Andrew Quitmeyer, Brian Hrolenok, Harry Shang, Dinh Bao Nguyen**, Tucker R. Balch, **Terrance Medina, Cole Sherer**, and Maria Hybinette, *International Conference of the Florida Artificial Intelligence Research Society (FLAIRS)*, 2012.
5. *Bio-Inspired Multi-Robot Communication through Behavior Recognition, **M. Novitzky, C. Pippin**, T.R. Collins, T.R. Balch, and M.E. West, *IEEE International Conference on Robotics and Biomimetics (ROBIO)*, 2012.
6. *Conditional Random Fields for Behavior Recognition of Autonomous Underwater Vehicles, **M. Novitzky, C. Pippin**, T.R. Collins, T.R. Balch, and M.E. West, *Distributed Autonomous Robotics Systems (DARS)*, 2012.
7. *Behavior Recognition of Autonomous Underwater Vehicles Using Forward-Looking Sonar, **M. Novitzky, C. Pippin**, T.R. Collins, T.R. Balch, and M.E. West, *Distributed Autonomous Robotics Systems (DARS)*, 2012.
8. *Incremental adaptive integration of layers of a hybrid control architecture, **M Powers**, T Balch, *Intelligent Robots and Systems (IROS)*, 2010
9. *A learning approach to integration of layers of a hybrid control architecture, **M Powers**, T Balch, *Intelligent Robots and Systems (IROS)*, 2009
10. *Graph-based planning using local information for unknown outdoor environments, **J Lee, R Mottaghi, C Pippin**, T Balch, *IEEE Intl Conf on Robotics and Automation (ICRA)*, 2009.
11. *Memory-based learning for visual odometry, **R Roberts, H Nguyen, N Krishnamurthi, T Balch**, *IEEE Intl Conf on Robotics and Automation (ICRA)*, 2008
12. *Cost based planning with RRT in outdoor environments, **J Lee, C Pippin**, T Balch, *Intelligent Robots and Systems (IROS)*, 2008.
13. *Real-time tracking of multiple targets using multiple laser scanners, **A Feldman, S Adams**, M Hybinette, T Balch, *Measuring Behavior*, 2008
14. *Control-driven mapping and planning, **D Wooden, M Powers**, DC MacKenzie, T Balch, M Egerstedt, *IEEE Intl Conf on Intelligent Robots and Systems (IROS)*, 2007
15. *Pervasive sensor-less networks for cooperative multi-robot tasks, **KJ O'Hara**, TR Balch, *Distributed Autonomous Robotic Systems (DARS)*, 2007
16. *Value-based communication preservation for mobile robots, **M Powers**, T Balch, *Distributed Autonomous Robotic Systems (DARS)*, 2007
17. *Incremental multi-robot task selection for resource constrained and interrelated tasks, **S Sariel**, T Balch, N Erdogan, *IEEE Intl Conf on Intelligent Robots and Systems (IROS)*, 2007
18. *A tracker for multiple dynamic targets using multiple sensors, **A Feldman, S Adams**, M Hybinette, T Balch, *IEEE Intl Conf on Robotics and Automation (ICRA)*, 2007
19. *Evaluation of a large scale pervasive embedded network for robot path planning, **KJ O'Hara, V Bigio, S Whitt**, D Walker, T Balch, *IEEE Intl Conf on Robotics and Automation (ICRA)*, 2006.

20. *Autopower: Toward energy-aware software systems for distributed mobile robots, KJ O'Hara, R Nathuji, H Raj, K Schwan, T Balch, *IEEE Intl Conf on Robotics and Automation (ICRA)*, 2006.
21. *Learning executable agent behaviors from observation, A Guillory, H Nguyen, T Balch, CL Isbell Jr, *International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*, 2006.
22. *A distributed multi-robot cooperation framework for real time task achievement, **S Sariel**, T Balch, *Distributed Autonomous Robotic Systems (DARS)*, 2006
23. *Empirical evaluation of auction-based coordination of AUVs in a realistic simulated mine countermeasure task, **S Sariel**, T Balch, J Stack, *Distributed Autonomous Robotic Systems (DARS)*, 2006
24. *Efficient Bids on Task Allocation for Multi-Robot Exploration, **S Sariel**, TR Balch, *International Conference of the Florida Artificial Intelligence Research Society (FLAIRS)*, 2006
25. *Learning and inference in parametric switching linear dynamic systems, **SM Oh**, JM Rehg, T Balch, F Dellaert, *IEEE Intl Conf on Computer Vision (ICCV)*, 2005
26. *Multitarget tracking with split and merged measurements, **Z Khan**, T Balch, F Dellaert, *Computer Vision and Pattern Recognition (CVPR)*, 2005.
27. *Data-driven MCMC for learning and inference in switching linear dynamic systems, **SM Oh**, JM Rehg, T Balch, F Dellaert, *National Conference on AI (AAAI)*, 2005
28. *What Are the Ants Doing? Vision-Based Tracking and Reconstruction of Control Programs. Egerstedt, M., Balch, T., Dellaert, F., **Delmotte, F.**, and **Khan, Z.** *IEEE International Conference on Robotics and Automation (ICRA)*, 2005
29. *Physical Path Planning Using the GNATs, **K.J. O'Hara** and **V.L. Bigio** and **E.R. Dodson** and **A. Irani** and D.B. Walker and T.R. Balch. *IEEE International Conference on Robotics and Automation (ICRA)*, 2005
30. *Data-Driven MCMC for Learning and Inference in Switching Linear Dynamic Systems, **Oh, S. M.**, Rehg, J., Balch, T., Dellaert, F., *National Conference on AI (AAAI)*, Pittsburgh, July 2005.
31. *An MCMC-Based Particle Filter for Tracking Multiple Interacting Targets, **Khan, Z.**, Balch, T., and Dellaert, F., *European Conference on Computer Vision (ECCV)*. 2004.
32. *Value-Based Action Selection for Exploration and Dynamic Target Observation with Robot Teams, **Stroupe, A.**, **Ravichandran, R.**, and Balch, T., *IEEE International Conference on Robotics and Automation (ICRA)*, 2004
33. *Gnats: Characterization of and experimentation with a pervasive embedded network, T Balch, **V Bigio**, **E Dodson**, **A Irani**, **K O'Hara**, D Walker, *IEEE International Conference on Robotics and Automation (ICRA)*, 2004
34. *Value-Based Communication Preservation for Mobile Robots, **Powers, M.**, and Balch, T. *Distributed Autonomous Robotic Systems (DARS)*. Toulouse, France. 2004.
35. *A Rao-Blackwellized Particle Filter for EigenTracking, **Z. Khan**, T. Balch, and F. Dellaert, *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2004.
36. *An MCMC-based particle filter for tracking multiple interacting targets, T Balch, F Dellaert, *European Conference on Computer Vision (ECCV)*, 2004
37. *Pervasive Sensor-less Networks for Cooperative Multi-Robot Tasks, **O'Hara, K.** and Balch, T., *Distributed Autonomous Robot Systems (DARS)*. 2004.
38. *Distributed Path Planning for Robots in Dynamic Environments Using a Pervasive Embedded Network. **O'Hara, K.**, and Balch, T. *International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*, 2004.

39. *Efficient Particle Filter-Based Tracking of Multiple Interacting Targets Using an MRF-based Motion Model, **Khan, Z.**, Balch, T., Dellaert, F., *IEEE International Conference on Intelligent Robots and Systems (IROS)*, 2003.
40. *Value-Based Observation with Robot Teams (VBORT) Using Probabilistic Techniques. **Stroupe, A.**, and Balch, T., *International Conference on Advanced Robotics (ICAR)*, 2003
41. *Protocols for Collaboration, Coordination and Dynamic Role Assignment in a Robot Team, **Emery, R., Sikorski, K.**, and Balch, T., *IEEE International Conference on Robotics and Automation (ICRA)*. Washington D.C., 2002.
42. *Collaborative Constraint-Based Multi-Robot Localization. **Stroupe, A.**, and Balch, T. *IEEE Intelligent Robot Systems (IROS)*. Lausanne, 2002.
43. *Automatically Tracking and Analyzing the Behavior of Live Insect Colonies, Balch, T., **Khan, Z.** and Veloso, M., *Autonomous Agents and Multiagent Systems (AAMAS)*, 2001
44. *Distributed Sensor Fusion for Object Position Estimation by Multi-Robot Systems. **Ashley W. Stroupe, Martin C. Martin** and Tucker Balch. *IEEE International Conference on Robotics and Automation (ICRA)*. Seoul, May 2001.
45. Behavior-Based Control of a Non-Holonomic Robot in Pushing Tasks, **Emery, R.** and Balch, T., *IEEE International Conference on Robotics and Automation (ICRA)*, Seoul, 2001.
46. Symmetry in Markov Decision Problems and implications for Single and Multiagent Learning. **Zinkevich, M.** and Balch, T., *IEEE International Conference on Machine Learning (ICML)*. 2001.
47. Merging Gaussian Distributions for Object Localization in Multi-Robot Systems. **Stroupe, A., Martin, M.**, and Balch, T. *Experimental Robotics VII (ISER)*. Rus and Singh (Eds). Springer, March 2001.
48. Behavior-Based Coordination of Large-Scale Robot Formations, Balch, T. and Hybinette, M., *IEEE International Conference on Multiagent Systems (ICMAS)*, Boston, 2000.
49. Integrating Information, Planning, and Execution Monitoring Agents, Veloso, M., Balch, T., and **Lenser, S.**, *Autonomous Agents (Agents)*, Barcelona, 2000.
50. Social Potentials for Scalable Multirobot Formations, Balch, T. and Hybinette, M., *IEEE International Conference on Robotics and Automation (ICRA)*, San Francisco, 2000.
51. Fast and Inexpensive Color Image Segmentation for Interactive Robots, **Bruce, J.**, Balch, T. and Veloso, M., *IEEE Intelligent Robot Systems (IROS)*. 2000.
52. Vision-Servoed Localization and Behaviors for an Autonomous Quadruped Legged Robot, Veloso, M., **Winner, E., Lenser, S., Bruce, J.**, and Balch, T., *Artificial Intelligence Planning Systems (AIPS)*, 2000.
53. Progress in RoboCup Soccer Research in 2000, M. Asada, A. Birk, E. Pagello, M. Fujita, I. Noda, S. Tadokoro, D. Duhaut, P. Stone, M. Veloso, T. Balch, H. Kitano, B. Thomas. *International Symposium on Experimental Robotics (ISER)*, Honolulu, Dec, 2000.
54. Fast Optical Hazard Detection for Planetary Rovers Using Multiple Spot Laser Triangulation, Matthies, L., Balch, T. and Wilcox B., *IEEE International Conference on Robots and Automation (ICRA)*, Albuquerque, NM, April 1997.
55. The Impact of Diversity on Performance in Robot Foraging, Balch, T., *Autonomous Agents (Agents)*, Seattle, WA, May, 1999.
56. Social Entropy: A New Metric for Learning Multirobot Teams, Balch, T., *International Conference of the Florida Artificial Intelligence Research Society (FLAIRS)*, Daytona, 1997.
57. Motor Schema-Based Formation Control for Multiagent Robot Teams, Balch, T. and Arkin R.C., *IEEE International Conference on Multiagent Systems (ICMAS)*, San Francisco, April 1995.

58. Dynamic Scheduling for Mobile Robots, Balch, T., Forbes, H., and Schwan, K., *6th EUROMICRO Workshop on Real-time Systems*, Vasteraas, Sweden, June 1994.
59. Communication of Behavioral State in Multi-Agent Retrieval Tasks, Arkin, R.C., Balch, T. and Nitz, E., *IEEE International Conference on Robots and Automation (ICRA-93)*, Atlanta, May 1993.
60. Avoiding the Past: A Simple but Effective Strategy for Reactive Navigation, Balch, T. and Arkin R.C., *IEEE International Conference on Robots and Automation (ICRA-93)*, Atlanta, May 1993, 678-685.

B3. Other refereed material

1. *Behavior Recognition of an AUV Using Forward-Looking Sonar. **Michael Novitzky, Charles Pippin**, Tucker Balch, Thomas Collins, and Michael E. West. *RSS Workshop on Marine Robotics*. July 2011.
2. *Improving Multirobot Multitarget Tracking by Communicating Negative Information. **Powers, M., Ravichandran, R.**, and Balch, T. Third International Multi-Robot Systems Workshop. Washington, D.C. March 2005.
3. *Niche Selection for Foraging Tasks in Multi-Robot Teams Using Reinforcement Learning. **Ulam, P.**, and Balch, T., *Proceedings of the 2nd International Workshop on the Mathematics and Algorithms of Social Insects*, 2003.
4. *Constraint-Based Landmark Localization. **Ashley W. Stroupe, Kevin Sikorski**, and Tucker Balch. *2002 RoboCup Symposium*, 2002.
5. Behavioral Diversity as Multiagent Cooperation, Balch, T., *SPIE '99 Workshop on Multiagent Systems*, Boston, 1999.
6. Integrating RL and Behavior-Based Control for Soccer, Balch, T., *RoboCup-97: Proceedings of the First Robot World Cup Soccer Games and Conferences*, Springer-Verlag, 1998.
7. JavaSoccer, Balch, T., *RoboCup-97: Proceedings of the First Robot World Cup Soccer Games and Conferences*, Springer-Verlag, 1998.
8. Robots Move (position paper on robot simulation), Balch, T., 1998. Working Notes of the AAI 1998 Spring Symposium, Stanford. 1998.
9. Lightweight Rovers for Mars Science Exploration and Sample Return, Schenker, P., Sword, L., Ganino, A., Bickler, D., Hickey, G., Brown, D., Baumgartner, E., Matthies, L., Wilcox, B., Balch, T., Aghazarian, H. and M. S. Garrett, *SPIE Intelligent Robotics and Computer Vision XVI, SPIE Proc. 320*, Pittsburgh, Oct. 14-17, 1997.
10. Design and Implementation of a Teleautonomous Hummer, Bentivegna, D.C., Ali, K.S., Arkin, R.C., Balch, T., *SPIE Conference on Mobile Robots XII*, Pittsburgh, Oct 1997.
11. Learning Roles: Behavioral Diversity in Robot Teams, Balch, T., *Proc. Of the 1997 AAI Workshop on Multiagent Learning*, Providence RI, July 1997.
12. Lessons Learned in the Implementation of a Multirobot Trash-Collecting Team, Balch, T., *AAAI 1995 Spring Symposium*, Stanford, March 1995.
13. Making a Clean Sweep: Behavior-Based Vacuuming, MacKenzie, D. and Balch, T., *AAAI Fall Symposium: Instantiating Real-world Agents*, Raleigh, NC, March 1993.
14. Buzz: An Instantiation of a Schema-Based Reactive Robotic System, Arkin, R.C., Balch, T., Collins, T., Henshaw, A., MacKenzie, D., Nitz, E., Rodriguez, R., and Ward, K., *International Conference on Intelligent Autonomous Systems: IAS-3*, Pittsburgh, Feb. 1993

B4. Submitted Journal Articles

None

C. OTHER PUBLICATIONS

1. Behavioral Diversity in Learning Robot Teams, Balch, T., Ph.D. Thesis, College of Computing, Georgia Institute of Technology, December, 1998.

D. PRESENTATIONS

1. Keynote: Machine Learning Applied to Investing, Market Technicians Association Annual Symposium, 2014
2. Keynote: How can AI and robotics help us understand social animal behavior?, *National Conference on AI (AAAI)*, 2005.

E. GRANTS AND CONTRACTS

E1. AS PRINCIPAL INVESTIGATOR

Title: Subcontract to Emory/Yerke's Study on Behavioral Effects of Hormones in Rhesus Monkeys

Sponsor: National Institutes of Health

Collaborators: Wallen, K. (PI at Yerkes), Walker, D. (co-PI)

Period: 9/1/2012 – 9/1/2013

Candidate's Share: 100% of \$120K

Title: Personal Robots for CS1: Next Steps for an Engaging Pedagogical Framework

Sponsor: National Science Foundation

Collaborators: Guzdial, M. (co-PI), Walker, D. (Senior Personnel), Summet, J. (Senior Personnel)

Period: 08/15/2009 to 07/31/2012

Candidate's Share: 75% of \$250K (\$187K)

Title: Personal Robots for Computer Science Education

Sponsor: Microsoft

Collaborators: Guzdial, M. (co-PI), Blank, D. (co-PI), Kumar, D. (co-PI)

Period: 1/1/2007 – 12/31/2009

Candidate's Share: 50% of \$1M (\$500K)

Title: Learning Visual Feature Graphs, Vision and Control for Ground Robots

Sponsor: DARPA/LAGR

Collaborators: Dellaert, F. (co-PI), Egerstedt, M. (co-PI), Rehg, J. (co-PI)

Period: 9/1/2004 to 8/31/2007

Candidate's Share: 33% of \$2,000,000 (\$660K).

Title: 2007 RoboCup International Symposium

Sponsor: National Science Foundation

Collaborator: None

Period: 6/1/2007 to 5/31/2008

Candidate's Share: 100% of \$20K

Title: NSF CAREER: Learning Executable Models of Physical Social Agent Behavior

Sponsor: National Science Foundation
Collaborator: None
Period: 3/15/2004 to 8/31/2010
Candidate's Share: 100% of \$500K

Title: Workshop on the Mathematics and Algorithms of Social Insects
Sponsor: National Science Foundation
Collaborator: None
Period: 11/15/2003 to 10/31/2004
Candidate's Share: 100% of \$35K

Title: Multiagent Control for Intelligent Minefields
Sponsor: Naval Surface Warfare Center
Collaborator: None
Period: 9/1/2004 – 8/31/2005
Candidate's Share: 100% of \$60K

Title: Sun Microsystems Equipment Grant.
Sponsor: Sun Microsystems.
Collaborator: None
Period: 3/1/2003
Candidate's Share: 100% of \$70K

Title: ITR: Observing, Tracking and Modeling Social Multi-agent Systems
Sponsor: National Science Foundation.
Collaborator: Dellaert, F. (co-PI)
Period: 9/1/2002 – 8/31/2006
Candidate's Share: 66% of \$450K (\$300K)

Title: Intel Equipment Grant
Sponsor: Intel.
Collaborator: Dellaert, F. (co-PI)
Period: 3/1/2002
Candidate's Share: 50% of \$25K (\$12.5K)

Title: TeamBots as a RoboCup Junior Simulation Platform,
Sponsor: Kitano Symbiotic, Japan
Collaborator: Maria Hybinette (co-PI)
Period: 4/1/2000 – 4/1/2001
Candidate's Share: 90% of \$40K (\$36K)

Title: Robot Swarms.
Sponsor: Northrop-Grumman.
Collaborator: Choset, H. (co-PI)
Period: 9/1/2000 – 9/1/2001
Candidate's Share: 50% of \$50K (\$25K)

E2. AS CO-PRINCIPAL INVESTIGATOR

Title: Collaborative Research: Automating the Large-Scale Measurement of Insect Behavior
 Sponsor: National Science Foundation
 Collaborators: Rehg, J. (PI), Pratt, S. (co-PI)
 Period: 09/01/2010 to 08/31/2014
 Candidate's Share: 50% of \$750K (\$375K)

Title: MURI: Heterogeneous Unmanned Teams (HUNT)
 Sponsor: US Navy
 Collaborators (at Georgia Tech): Arkin, Ron (PI), Egerstedt, M. (co-PI)
 Period: 7/1/2008 to 12/31/2014
 Candidate's Share: 32% of \$1M (\$320K)

Title: HCC: Medium: The Accessible Aquarium Project: Access to Dynamic Informal Learning Environments via Advanced Bio-Tracking and Adaptive Sonification
 Sponsor: National Science Foundation
 Collaborators: Walker, B. (PI), Bobick, A. (co-PI), Bruce, C. (co-PI), Weinberg, G. (co-PI)
 Period: 08/01/2009 to 07/31/2014
 Candidate's Share: 20% of \$1.2M (\$240K)

Title: ITR: Collaborative Research: Morphable Software Services: Self-Modifying Programs for Distributed Embedded Systems
 Sponsor: National Science Foundation
 Collaborators: Schwan, K. (PI), Pu, C., Pande, S., Eisenhauer, G.
 Period: 10/01/2003 to 09/30/2008
 Candidate's Share: 25% of \$1M (\$250K)

Title: Reconnaissance, Surveillance and Targeting Unmanned Ground Combat Vehicle.
 Sponsor: UGCV Program, DARPA.
 Collaborators: Catalan, M. (PI) (Battelle), Dodson, M. (co-PI)(Battelle)
 Period: 11/1/2000 – 12/31/2001
 Candidate's Share: 20% (\$100K)

E3. AS SENIOR PERSONNEL OR CONTRIBUTOR

NONE

E4. PROPOSALS SUBMITTED BUT NOT FUNDED (last two years)

Title: Collaborative Research: The role of individual heterogeneity in collective choice, analyzed with automated video techniques
 Sponsor: National Science Foundation
 Collaborators: Rehg, J., Pratt, S.

E5. IN PREPARATION

Title: Automated Tracking and Online Behavior Analysis of Rhesus Macaque at Scale
 Sponsor: National Institutes of Health
 Collaborators: Wallen, K. (Yerkes), Rehg, J.

F. OTHER SCHOLARLY ACCOMPLISHMENTS**Lucena Research, LLC (Startup), 2011-Present**

Lucena provides decision support software for investment professionals, hedge funds and wealth managers. The company's products are based on financial algorithms and methods I teach about and research at Georgia Tech. I co-founded Lucena as a Georgia Tech spinoff with Erez Katz and John Cornwell (a CoC MSCS alum). Our company was in the first cohort at Georgia Tech's Flashpoint startup accelerator. As of this writing, Lucena has 10 employees, and has raised over \$2M in startup capital. I serve with Lucena as a consultant and CTO.

Georgia Robotics, Inc. (Non-Profit), 2007-Present

Georgia Robotics' mission is to support robotics research and education. The company manufactures and sells educational robots based on a license from Georgia Tech. The design is based on work originally funded by Microsoft and the NSF. GRI also organizes and manages large research conferences: RoboCup 2007 (2,200 attendees), ICML 2013 (850 attendees). I am the president of Georgia Robotics.

QSTK (Software), 2010-Present

The QuantSoftware ToolKit (QSTK) is an open source toolkit for investment research. I developed this software to support my course at Georgia Tech and the MOOC Computational Investing. Over 40,000 people have downloaded QSTK.

G. SOCIETAL AND POLICY IMPACTS

Educational Robotics: The curricula, book and robot I helped develop are used by more than 30 institutions. Over 5,000 students have used our robot to learn Computer Science. The robot is also used at Georgia Tech to teach about 500 students per year.

Computational Investing Education: The MOOC I created is possibly the most popular course on this topic. More than 100,000 people have enrolled in the course, with 5,000 having completed it.

V. TEACHING**A. COURSES TAUGHT**

Semester, Year	Course Number	Course Title	Number of Students
Fall, 2013	CS 7646: Machine Learning for Trading		73
		Computational Investing, Part I (Coursera)	25,000
Spring, 2013		no on campus teaching – “bought out”	
		Computational Investing, Part I (Coursera)	25,000
Fall, 2012	CS 7646: Machine Learning for Trading		87
		Computational Investing, Part I (Coursera)	54,000
Spring, 2012	CS 7631: Multi-Robot Systems		28
Fall, 2011	CS 7646: Machine Learning for Trading		48
Spring, 2011		no teaching – taught two courses in Fall 2011	
Fall, 2010	CS 7631: Multi-Robot Systems		47
Fall, 2010	CS 8803: Machine Learning for Trading		44
Spring, 2010	CS 8803: Machine Learning for Trading		32
Fall, 2009		no teaching – on leave	
Spring, 2009		no teaching – on leave	
Fall, 2008	CS 4632: Advanced Intelligent Robotics		19
Fall, 2008	CS 7631: Multi-Robot Systems		24
Spring, 2008	CS 3650: Prototyping Intelligent Appliances		12

(Courses taught before 2008 are not listed per Provost’s direction)

B. INDIVIDUAL STUDENT GUIDANCE**B1. Postdoctoral Fellows**

None

B2. Ph.D. Students

Brian Hrolenok, current CS Ph.D. student

Research: Learning social behavior through live animal observation

Advisement began: Fall 2011

Status: Completed CS qualifier Spring 2014

Research output with me: 5 conference and workshop publications, journal in progress

Michael Novitzky: current Robotics Ph.D. student

Research: Modifying robot trajectories to enable behavior recognition

Advisement began: Fall 2009

Status: Completed Robotics qualifier Spring 2014

Research output with me: 4 conference papers, 1 journal article

Keith O'Hara, Ph.D.: Ph.D. Georgia Institute of Technology 2011
Dissertation: Leveraging Distribution and Heterogeneity in Robot Systems Architecture
Status: Assistant Professor at Bard College
Research output with me: 9 conference papers, 2 journal articles

Matthew Powers, Ph.D.: Ph.D. Georgia Institute of Technology 2010
Dissertation: Applying Inter-Layer Conflict Resolution to Hybrid Robot Control Architectures
Status: Senior Robotics Engineer at Carnegie Mellon University
Research output with me: 6 conference papers, 2 journal articles

Adam Feldman, Ph.D.: Ph.D. Georgia Institute of Technology 2008
Dissertation: Using Observations to Recognize the Behavior of Interacting Multi-Agent Systems
Status: Product Manager at Google
Research output with me: 2 conference papers, 4 journal articles

Sanem Sariel-Talay, Ph.D.: Ph.D. Istanbul Technical University 2007
Sanem worked with me as a visiting scholar from 2004 to 2006. The bulk of research for her dissertation was completed with me at Georgia Tech. She was co-advised with me by Prof. Nadia Erdogan of ITU.
Status: Assistant Professor at Istanbul Technical University
Research output with me: 4 conference papers, 2 journal articles

Ashley Stroupe, Ph.D.: Ph.D. Carnegie Mellon University 2003
Ashley was my student at CMU before I left to join Georgia Tech in 2001. I retained an appointment at CMU, and she completed her degree under my advisement.
Dissertation: Collaborative Execution of Exploration and Tracking using Move Value Estimation for Robot Teams (MVERT)
Status: Member of Engineering Staff, NASA Jet Propulsion Lab
Research output with me: 7 conference papers, 1 journal article

B3. M.S. Students

I am currently research advisor for the following MSCS students:

Alex Moreno
Richard Brooks
Jayita Bhattacharya
Jun Wang
Swetha Shivakumar
Spurthi Amba Hombaiah
Weinflash, Joshua

I previously advised the following MS students:

Hanuma Teja Maddali: MS ECE Georgia Institute of Technology, 2014 (expected)

Thesis: Inferring Social Structure and Dominance Relationships Between Rhesus macaques using RFID Tracking Data

Research output with me: 2 conference papers

Sourabh Bajaj, M.S.: MSCS, Georgia Institute of Technology, 2012

Research: Machine Learning for Trading

Status: Developer, Coursera

Shreyas Joshi, M.S.: MSCS, Georgia Institute of Technology, 2011

Research: Machine Learning for Trading

Status: Developer, AQR (Hedge Fund)

Harikrishna Narayanan, MS: MSCS, Georgia Institute of Technology, 2010

Research: Machine Learning for Trading

Status: Developer, Yahoo! Finance

Kevin Sikorski, M.S.: M.S. Carnegie Mellon University Robotics 2001

Research: Reinforcement learning and behavior-based control of robot teams

Status: Senior Software Engineer, The IMS Company

Rohit Sharma, M.S.: MS ISYE, Georgia Institute of Technology, 2003.

Research: HMM/Baum-Welch.

Status: Senior VP, Black Rock Investments

Victor Bigio, M.S.: MSCS, Georgia Institute of Technology, 2005.

Research: distributed control of robot teams

Status: Software Engineer, NASA/Goddard

Eric Dodson, M.S.: MSCS, Georgia Institute of Technology, 2005.

Research: distributed control of robot teams

Status: Software Engineer, Harris Corporation

B4. Undergraduate Students

James Bruce, Ph.D.: B.S., Ph.D. Carnegie Mellon University

Research: Color vision based tracking, advised with Manuela Veloso

Status: Developer at Google

Research output with me: 2 conference papers

Other undergraduate students I have advised:

Andrew Stein

Stephen Culpepper

Jason Fortner

Richard Guily

B5. Service on thesis or dissertation committees

Amin Atrash, Eric Martinsen, Lilia Moshkina, Yochiro Endo, Tracy Westyn, Alan Wagner, Ananth Ranganathan, Darrin Bentivegna, Alex Stoychev, Robert Zlot, Brett Browning, Ashley Tews, Daniel Rodic.

B6. Mentorship visiting scholars

Sourabh Bajaj: After working with me for 1 year as a visiting undergrad, Sourabh enrolled as an MSCS student at Georgia Tech. He is now at Coursera.

Sanem Sariel, Istanbul Technical University. After initially working with her as a visiting scholar, Sanem became my Ph.D. student. She is now an assistant professor at ITU.

C. OTHER TEACHING ACTIVITIES

Computational Investing (Massive Online Open Course), 2012-Present

This was the first MOOC offered by Georgia Tech. It is based on the first half of my on campus course. The MOOC version of the course was first offered in Fall 2012, and has since then been offered twice more. This course is arguably the most successful of Georgia Tech's MOOCs, with more than 100,000 students enrolling, and 5,000 completing the course.

Personal Robots for Computer Science Education

Starting in 2008, I led a team of Georgia Tech researchers in collaboration with educators at Bryn Mawr College in the creation of a curriculum, software, textbook and robot hardware to teach introductory computer science. The work was initially funded by Microsoft and then the NSF. Collaborators included Prof. Mark Guzdial, Dr. Jay Summet and Daniel Walker at Georgia Tech and Prof. Doug Blank and Prof. Deepak Kumar at Bryn Mawr. The curricula is in use at over 30 institutions. More than 5,000 of these educational robots have been sold.

VI. SERVICE

A. PROFESSIONAL CONTRIBUTIONS

Lead Organizer, International Conference on Machine Learning, ICML-2013, Atlanta, Georgia
This is the premier international Machine Learning conference, with over 800 attendees.

Lead Organizer, RoboCup 2007, Atlanta, Georgia

This is the premier international robotics research competition, with over 2100 attendees

Chair and Organizer, International Workshop on the Algorithms and Mathematics of Social Insects, 2003.

Vice President and Board of Trustees, The RoboCup Federation, 2001-Present

Reviewer for: Autonomous Robots (Journal), Journal of Field Robotics, IEEE Transactions on Robotics, IEEE Transactions on Systems, Man and Cybernetics, Robotics and Autonomous Systems (Journal), ACM SIGGRAPH, ICRA, IROS, AAMAS, SPIE, many others.

B. PUBLIC SERVICE

None.

C. COMMUNITY SERVICE

Chair, City of Suwanee Zoning Board of Appeals, 2004

Member, City of Suwanee Zoning Board of Appeals, 2003-2009

D. INSTITUTE CONTRIBUTIONS

- Member, Georgia Tech Executive Board, 2013-Present
- Member, MOOC Task Force, 2013-Present
- Member, Georgia Tech Statutes Committee, 2011, 2012
- Senator, Georgia Tech Faculty Senate, 2011, 2012
- Chair, Faculty Hiring Committee, School of Interactive Computing, 2012, 2013
- Member, Faculty Hiring Committee, School of Interactive Computing, 2010, 2011
- Proposed and drafted Bylaws for the faculty of the School of Interactive Computing, 2011.
- Created the proposal for the Center for Robotics and Intelligent Machines (with Henrik Christensen and Aaron Bobick), 2007.
- Created the proposal for the Ph.D. program in Robotics (with Frank Dellaert and Harvey Lipkin), 2008