

## Resume of Paul Benjamin

Professor of Computer Science  
School of Computer Science and Information Systems  
Pace University  
1 Pace Plaza  
New York, NY 10038

benjamin@pace.edu  
<http://csis.pace.edu/~benjamin>  
<http://csis.pace.edu/robotlab>

### Education:

Ph.D.	Computer Science - Courant Institute, New York University
M.S.	Computer Science - Courant Institute, New York University
B.F.A.	Music - Carnegie-Mellon University
M.S.	Mathematics - Carnegie-Mellon University
B.S.	Mathematics - Carnegie-Mellon University
Diploma	Shady Side Academy

### Research Interests:

- Design of cognitive architectures in robotics, focusing on the relationship between perception, problem solving and language
- Building intelligent systems for cybersecurity, especially network intrusion detection
- Application of semigroup and dynamical systems theory to knowledge representation and reformulation, problem solving and learning
- Reformulation and solution of distributed constraint satisfaction problems

### Current Employment:

Pace University, School of Computer Science and Information Systems, 1997 – Present  
Professor of Computer Science  
Director of the Robotics Laboratory  
Director of the Ph.D. program  
Department Chair, 2000 - 2003

## **Sponsored Research:**

Office of Naval Research DURIP grant, "A Humanoid Robot Hand for Dexterous Manipulation", Award N00014-22-1-2285, \$59,585, Sept. 1, 2022– August 31, 2023.

National Science Foundation, CyberCorps Scholarship for Service: Strengthening Cyber Community and Pathways Using Research Experiences, Technical Training and Institutional Outreach, \$3,856,432, Award Number 2043095, PI: Li-Chiou Chen, Co-PIs: D. Paul Benjamin, Andreea Cotoranu, Darren Hayes, Joseph F. Ryan, Sept. 1, 2021 – August 31, 2026.

Office of Naval Research DURIP grant, "A Humanoid Robot for Investigating Spatial Understanding in Human-Robot Collaboration", Award N00014-19-1-2546, \$185,813, Sept. 1, 2019 – August 31, 2021.

Army Research Office DURIP grant, "Virtual Network Computing Testbed for Cybersecurity Research", \$110,000, 2013 - 2014.

Army Research Office, "A Multi-scale Cognitive Approach to Intrusion Detection and Response", \$294,944, July 15, 2010 – July 14, 2014.

DARPA, "Cognitive Support for Survivability Against Sophisticated Attacks", contract N00178-07-C-2003, \$1.5 million with BBN Technologies, Inc., December 2006 - June 2008.

Department of Energy, "Integrating Perception and Action Through Local Symmetries and Invariants", award number ER 45903, \$296,079, September 2001 - August 2005.

National Science Foundation, "Integrating Formal Methods Tools into the Undergraduate Curriculum", PI: Prof. Sotiris Skevoudis, Co-PIs: Prof. P. Benjamin and Prof. D. Anderson, Award No. DUE-0126991, \$73,423, September 2002 - August 2005.

Hudson Valley Center for Emerging Technologies, "Hudson Valley Intelligent Agents Laboratory", \$10,000, 2001.

Air Force Office of Scientific Research / Rome Laboratory, "Pragmatic Approaches to Composition and Verification of Assured Software", \$80,500, with Dr. Shiu-Kai Chin of Syracuse University and Dr. Susan Older of Syracuse University, 1998.

Air Force Office of Scientific Research, "Formal Approaches to Software Design, Planning, and the Design of Secure Systems", \$105,915, Grant No. F49620-93-C-0063, October 1, 1997 - September 30, 1998.

National Science Foundation, "Reformulation of System Theories in Robotics", \$49,678, SGER grant 9509537, August 1, 1995 - March 31, 1998.

Air Force Office of Scientific Research / Rome Laboratory, "Embedding Process and Specification Descriptions within a Categorical Framework for Refinement and Composition", \$76,000, with Dr. Shiu-Kai Chin of Syracuse University, January 1997 - September 1997.

Air Force Office of Scientific Research, "Application of Decomposition and Reformulation to Transportation Scheduling", \$103,831, Grant No. F49620-93-C-0063, October 1, 1996 - September 30, 1997.

Air Force Office of Scientific Research / Rome Laboratory, "Application of Process Algebra and Logic", \$82,613, with Dr. Shiu-Kai Chin of Syracuse University, May 1996 - December 1996.

Air Force Office of Scientific Research, "Reformulating Domain Theories to Improve Their Computational Usefulness", \$24,807, SREP grant, January 1996 - December 1996.

Air Force Office of Scientific Research, "Transformational Software Design by Decomposition using the Kestrel Interactive Development System", \$24,970, SREP grant, January 1995 - December 1995.

### **Refereed Publications:**

"A Fast Parallel Algorithm for Comparing Real and Synthetic Video", Xiaodong Xu, D. Paul Benjamin, Biologically Inspired Cognitive Architectures 2024: Proceedings of the 15th Annual Meeting of the BICA Society, in *Studies in Computational Intelligence*, Springer 2024.

"Convolutional Neural Networks for Breast Ultrasound Image Segmentation", Yaobin Liang, Juan Shan, D. Paul Benjamin, Rania Almajalid, *IEEE EMBS International Conference on Biomedical & Health Informatics (BHI)*, 2019.

"Spatial Understanding as a Common Cognitive Basis for Human-Robot Collaboration", D. Paul Benjamin, Tianyu Li, Peiyi Shen, Hong Yue, Zhenkang Zhao, Damian Lyons, in *Advances in Human Factors in Robots and Unmanned Systems*, pp.23-30, DOI: 10.1007/978-3-319-60384-1\_3, January, 2018.

"Classification and Prediction of Human Behaviors by a Mobile Robot", D. Paul Benjamin, Hong Yue, and Damian M. Lyons, in *Advances in Human Factors in Robots and Unmanned Systems*, pp.189-195, DOI: 10.1007/978-3-319-41959-6\_16, January 2017.

"Progress in Building a Cognitive Vision System", D. Paul Benjamin, Damian Lyons and Hong Yue, *SPIE Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications*, April 2016.

"Using a 3D World to Address Perceptual Issues in Human-robot Coordination", D. Paul Benjamin, Damian M. Lyons, *Procedia Manufacturing*, Vol. 3, 2015, pp.1030–1037, doi:10.1016/j.promfg.2015.07.165

"Effects of Using a 3D Model on the Performance of Vision Algorithms", Damian Lyons, D. Paul Benjamin and Robert Lynch, *SPIE Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications*, April 2015.

"A Cognitive Approach to Vision for a Mobile Robot", D. Paul Benjamin, Damian Lyons, and Christopher Funk, *SPIE Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications*, April 2013.

"Navigation of Uncertain Terrain by Fusion of Information from Real and Synthetic Imagery", Damian Lyons, Paramesh Nirmal and D. Paul Benjamin, *SPIE Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications*, April 2012.

"Using a Virtual World for Robot Planning", D. Paul Benjamin, Damian Lyons, John V. Monaco, Yixia Lin, and Christopher Funk, *SPIE Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications*, April 2012.

"A Relaxed Fusion of Information from Real and Synthetic images to Predict Complex Behavior", Damian Lyons and D. Paul Benjamin, *SPIE Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications*, April 2011.

"Comprehension and Prediction of Astronaut Dynamics", by D. Paul Benjamin, Damian M. Lyons, John Vincent Monaco and Yixia Lin, *IEEE Aerospace Conference*, March 2011.

"A Visual Imagination Approach to Cognitive Robotics", by Damian M. Lyons, Sirhan Chaudhry, and D. Paul Benjamin, *Symposium on Understanding the Mind and Brain*, Tucson, Arizona, May 2010.

"A Cognitive Approach to Classifying Perceived Behaviors", by D. Paul Benjamin and Damian M. Lyons, *SPIE Conference on Multisensor, Multisource Information Fusion*, April 2010.

"Integrating Perception and Problem Solving to Predict Complex Object Behaviors", by Damian M. Lyons, Mohamed Chaudhry, D. Paul Benjamin, Marius Agica, John Vincent Monaco, *Conference on Multisensor, Multisource Information Fusion, SPIE*, April 2010.

"Locating and Tracking Objects by Efficient Comparison of Real and Predicted Synthetic Video Imagery", by Damian M. Lyons and D. Paul Benjamin, *Conference on Intelligent Robots and Computer Vision, SPIE*, San Jose, Calif., January 2009.

"Anomaly and Specification Based Cognitive Approach for Mission-Level Detection and Response", by Paul Rubel, Partha Pal, Michael Atigetchi, Paul Benjamin and Franklin Webber, *11th International Symposium On Recent Advances In Intrusion Detection (RAID 2008)*, Boston, MA, September 15-17, 2008. Also published in *Recent Advances in Intrusion Detection, Lecture Notes in Computer Science*, Vol. 5230/2008, pp. 408-409.

"Using Cognitive Semantics to Integrate Perception and Motion in a Behavior-Based Robot", with Deryle Lonsdale, Damian Lyons and Siddharth Patel, *Proceedings of the 2008 ECSIS Symposium on Learning and Adaptive Behavior in Robotic Systems (LAB-RS 2008)*, IEEE Computer Society, August 6-8, 2008, Edinburgh, Scotland.

"Using A Cognitive Architecture to Automate Cyberdefense Reasoning", with Partha Pal, Franklin Webber, Paul Rubel, Mike Atigetchi, *Proceedings of the 2008 ECSIS Symposium on Bio-inspired, Learning, and Intelligent Systems for Security (BLISS 2008)*, IEEE Computer Society, August 4-6, 2008, Edinburgh, Scotland.

"Automating Cyber-Defense Management", with Partha Pal, Franklin Webber, Michael Atigetchi and Paul Rubel, *Proceedings of the 2<sup>nd</sup> Workshop on Recent Advances in Intrusion-Tolerant Systems (WRAITS08)*, Glasgow, Scotland, 2008.

"A Cognitive Approach to Intrusion Detection", *Proceedings of the IEEE Conference on Computational Intelligence for Security and Defense Applications 2007 (CISDA2007)*, Honolulu, Hawaii, April 2007.

"A Cognitive Robotics Approach to Comprehending Human Language and Behaviors", with Deryle Lonsdale and Damian Lyons, *Proceedings of the Human-Robot Interaction Conference 2007 (HRI2007)*, Washington, D.C., March 2007.

"A Fast Predictive Vision System for a Mobile Robot", with Tom Achemichuk and Damian Lyons, *AAAI Fall Symposium on Image Comprehension*, Washington, D.C., October 2006.

"Embodying a Cognitive Model in a Mobile Robot", with Deryle Lonsdale and Damian Lyons, *SPIE Conference on Intelligent Robots and Computer Vision*, Boston, October 2006.

"Integrating Language Modeling Components for Robotic Interaction", by Deryle Lonsdale, Rebecca Madsen and Paul Benjamin, *Human Robot Interaction '06*, Salt Lake City, Utah, 2006.

"Obstacle Avoidance using Predictive Vision based on a Dynamic 3D World Model", with Thomas Achtemichuk and Damian Lyons, *Proceedings of the SPIE Conference on Intelligent Robots and Computer Vision*, Boston, October 2006.

"Developing a Cognitive Architecture to be Embedded in the Physical World", with Deryle Lonsdale and Damian Lyons, *Proceedings of BRIMS2006 (Behavior Representation in Modeling and Simulation)*, Baltimore, May 2006.

"Semantic Encoding of Relational Databases in Wireless Networks", with Adrian Walker, *Proceedings of the SPIE Defense Symposium on Data Mining, Intrusion Detection, Information Assurance and Data Networks Security*, Orlando, Florida, March-April 2005.

"VMSoar: A Cognitive Agent for Network Security", with Ranjita Shankar-Iyer and Archana Perumal, *Proceedings of the SPIE Defense Symposium on Data Mining, Intrusion Detection, Information Assurance and Data Networks Security*, Orlando, Florida, March-April 2005.

"Designing a Robot Cognitive Architecture with Concurrency and Active Perception", with Damian Lyons and Deryle Lonsdale, *Proceedings of the AAI Fall Symposium on the Intersection of Cognitive Science and Robotics*, Washington, D.C., October 2004.

"ADAPT: A Cognitive Architecture for Robotics", with Damian Lyons and Deryle Lonsdale, *International Conference on Cognitive Modeling*, (ICCM-2004), Pittsburgh, Pa., July 2004.

"Cognitive Robots: Integrating Perception, Action and Problem Solving in Behavior-based Robots", with Damian Lyons and Deryle Lonsdale, *AAMAS-2004 proceedings*, pp. 1308-1309, New York City, July 2004.

"Undergraduate Cybersecurity Projects", D. Paul Benjamin, Charles Border, Robert Montante, Paul Wagner, *SIGCSE2003 Proceedings*, Reno, Nevada, 2003.

"Evolving Efficient Security Systems Under Budget Constraints Using Genetic Algorithms", Michael L. Gargano, P. Benjamin, W. Edelson, and P. Meisinger, *Proc. 34th Southeastern International Conference on Combinatorics, Graph Theory and Computing*, 2003.

"On the Emergence of Intelligent Global Behaviors from Simple Local Actions", *International Journal of Systems Science*, special issue: Emergent Properties of Complex Systems, Vol. 31, No. 7, pp. 861-872, 2000.

"Connecting Perception and Action by Associating Symmetries in Vision and Language", *International Journal of Artificial Intelligence Tools*, Vol. 8, No. 3, 1999.

"Decomposing Robotic Representations by Identifying Local Symmetries and Invariants", *Proceedings of the NSF Design and Manufacturing Grantees Conference*, Mexico, 1998.

"A Decomposition Approach to Solving Distributed Constraint Satisfaction Problems", *Proceedings of the IEEE Seventh Annual Dual-use Technologies & Applications Conference*, IEEE Computer Society Press, 1997.

"Reformulating Theories of Action for Efficient Planning", in *Theories of Action, Planning and Robot Control: Bridging the Gap*, Chitta Baral (ed.), AAI Press, 1996.

"Transforming System Formulations in Robotics for Efficient Perception and Planning", *Proceedings of the IEEE International Symposia on Intelligence and Systems*, Washington, D.C., IEEE Computer Society Press, 1996.

"The Design of Effective Formulations in Artificial Intelligence and Robotics", *Proceedings of the Conference on Notational Engineering*, George Washington University, May 1996.

"Formulating Systems", *Proceedings of the 28th IEEE Southeastern Symposium on System Theory*, IEEE Computer Society Press, April 1996.

"Behavior-preserving Transformations of System Formulations", *Proceedings of the AAI Spring Symposium on Learning Dynamical Systems*, Stanford University, March 1996.

"Formulating Domain Theories for Software Design", *Proceedings of the IEEE Sixth Annual Dual-use Technologies & Applications Conference*, IEEE Computer Society Press, 1996.

"Reformulating Domain Theories for Reuse in Problem Solving", in *Adaptation of Knowledge for Reuse, Papers from the 1995 Fall Symposium*, D. Aha & A. Ram (eds.), AAAI Press, 1995.

"Analyzing Languages of Action for the Purpose of Synthesis", in *Extending Theories of Action: Formal Theory & Practical Applications: Papers from the 1995 AAAI Symposium*, Craig Boutilier & Moises Goldszmidt (eds.), AAAI Press, 1995.

"Prototype and Delegation-based Approach in Expert System Design", by Jarernsri L. Mitrpanont, K. M. George, and D. Paul Benjamin, *Proceedings of the Computers in Engineering Symposium, Energy-sources Technology Conference*, American Society of Mechanical Engineers, 1994.

"Formulating Patterns in Problem Solving", *Annals of Mathematics and AI*, Vol. 10, pp.1-23, 1994.

"Reformulating Path Planning Problems by Task-preserving Abstraction", *Journal of Robotics and Autonomous Systems*, 9, pp. 1-9, 1992.

"Towards an Effective Theory of Reformulation", in *Proceedings of the Workshop on Change of Representation and Problem Reformulation*, Michael R. Lowry (ed.), NASA Ames Research Center Technical Report FIA-92-06, pp.13-27, April 1992.

"Integrating Perception with Problem Solving", D. Paul Benjamin, Alec Cameron, Leo Dorst, Madeleine Rosar, and Hsiang-Lung Wu, *Proceedings of the AAAI Spring Symposium on Integrated Intelligent Architectures*, Stanford University, March, 1991. Also published in SIGART, Vol. 2, No. 4, August 1991, pp. 41-45.

"An Algebraic Approach to Abstraction and Representation Change", by D. Paul Benjamin, Leo Dorst, Indur Mandhyan, and Madeleine Rosar, in *Proceedings of the AAAI-90 Workshop on Automatic Generation of Approximations and Abstractions*, Boston, July 1990.

"A Metalevel Manifesto", in *Machine Learning, Meta-Reasoning, and Logics*, Pavel B. Brazdil and Kurt Konolige (eds.), Kluwer Academic Publishers, 1990.

"An Overview of Adaptive Task Planning", by Damian Lyons, Richard Pelavin, Antonius Hendriks, and D. Paul Benjamin, in *Proceedings of the AAAI Spring Symposium on Planning in Uncertain, Unpredictable, and Changing Environments*, Stanford, 1990.

"An Introduction to the Decomposition of Task Representations in Autonomous Systems", D. Paul Benjamin, Leo Dorst, Indur Mandhyan, and Madeleine Rosar, in *Change of Representation and Inductive Bias*, D. Paul Benjamin (ed.), Kluwer Academic Publishers, 1989.

"A Method for Creating Hierarchical Representations that Serialize Subgoals", in *Proceedings of the AAAI Spring Symposium on Search and Planning*, Stanford University, 1989.

"Using a Metatheory as a Functional Representation", *International Journal of Intelligent Systems*, 3(3), pp. 295-314, 1988.

"Learning Search Control Knowledge Within a Metalevel Representation", *Proceedings of the AAAI Spring Symposium on Explanation-Based Learning*, Stanford University, 1988.

"Learning Strategies by Reasoning about Rules", *Proceedings of the Tenth International Joint Conference on Artificial Intelligence (IJCAI87)*, 1987.

"Extraction and Generalization of Expert Advice", doctoral dissertation, Courant Institute of Mathematical Sciences, New York University, 1985.

"A Production System for Learning Plans from an Expert", D. Paul Benjamin and Malcolm C. Harrison, *Proceedings of the National Conference on Artificial Intelligence (AAAI83)*, 1983.

### **Patents Held:**

"System for Intrusion Detection and Vulnerability Assessment in a Computer Network using Simulation and Machine Learning", U.S. Patent No. 7784099, 2010, with Pace University.

"Semantic Encoding and Compression of Database Tables", U.S. Patent 6,691,132, February, 2004, in partnership with Adrian Walker of Reengineering, LLC.

### **Professional Contributions:**

Program Committee member for conference on Biologically Inspired Cognitive Architectures, 2015-2024.

Program Committee, SPIE Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications, 2011 - 2016.

Program Committee, IEEE Workshop on Human-Machine Systems, Cyborgs and Enhancing Devices, 2013.

Reviewer for 13th International Conference on Control, Automation, Robotics and Vision, ICARCV 2013.

Reviewer for HRI2013 - 8th ACM/IEEE conference on Human-Robot Interaction.

Program Committee, EST-2010, International Conference on Emerging Security Technologies, Canterbury, UK, September 2010.

Panelist: SPIE Conference on Multisensor, Multisource Information Fusion, April 2010.

Program Committee, LAB-RS2009, Romania, August 2009.

Panelist: Robotics in Education and Session Chair: Learning in Robotics, LAB-RS2008, Edinburgh, Scotland, 2008.

Panelist: Intelligent Systems Panel, IIMA-2006, Westchester, N.Y., October 2006.

Panelist: Cybersecurity Education Panel, SIGCSE2003, Las Vegas, February 2003.

Reviewer for funding agencies, conferences and journals, 1988-present, including ARO, NSF, HRI2009, ICCM, CogSci2006, BRIMS2006, IIMA-2007.

Program Committee, 10th Colloquium on Information Systems Security Education, 2005.

Program Committee, Conference on High Assurance Software Engineering - HASE'98, 1998.

Program Committee, Tenth International Conference on Software Engineering and Knowledge Engineering - SEKE'98, San Francisco, June 1998.

Session chair: Sensors and Signal Processing, and Panelist, Intelligence in Automation, IEEE International Joint Symposia on Intelligence and Systems, Washington, D.C., 1998.

Editor of the book "Change of Representation and Inductive Bias", Kluwer, 1990.

Program chair and organizer, Workshop on Algebraic Approaches to Representation and Problem Solving, Westchester, NY, 1990.

Program chair and organizer, Workshop on Category Theory in AI and Robotics, NY, 1989.

Program committee and local arrangements chair, First Workshop on Change of Representation and Inductive Bias, Westchester, NY, June 1988.

Program chair, PHILIPS International AI Conference, England, May 1988.

Panelist, Knowledge engineering, ACM-IEEE Fall Joint Computer Conference, 1986.

### **Previous Employment:**

1996 – 1998: Rome Laboratory, Air Force Office of Scientific Research  
Visiting Research Professor

1995 – 1997: Syracuse University, Dept. of Electrical Engineering and Computer Science  
Visiting Assistant Professor

May - August, 1995: Rome Laboratory, Griffiss Air Force Base, Rome, NY  
Air Force Office of Scientific Research Summer Research Fellow

May - August, 1994: Rome Laboratory, Griffiss Air Force Base, Rome, NY  
Air Force Office of Scientific Research Summer Research Fellow

1992 – 1995: Oklahoma State University, Department of Computer Science  
Assistant Professor

1991 – 1992: St. Joseph's University (Philadelphia, Pa.),  
Visiting Assistant Professor, Department of Mathematics and Computer Science

1984 – 1990: Philips Research Laboratory, Briarcliff Manor, NY  
Senior Member of Research Staff, Project Leader in Machine Learning, 1985 - 1987

**Professional Affiliations:** AAAI, ACM, Sigma Xi.

**Personal:** U.S. Citizen. Married, with two daughters. My interests include chess and music.