Justin Werfel

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Research Interests

Artificial and natural intelligence in multiagent systems, swarm and modular robotics, collective behavior, complex and emergent systems, social animal behavior, evolutionary theory, molecular and cellular systems, educational technology, bioinspired engineering.

Education

Massachusetts Institute of Technology — Cambridge, MA
Ph.D., Computer Science, June 9, 2006
Minor: Brain & Cognitive Sciences
Dissertation: Anthills Built to Order: Automating Construction with Artificial Swarms
Advisors: Radhika Nagpal, H. Sebastian Seung

Massachusetts Institute of Technology — Cambridge, MA
S.M., Electrical Engineering and Computer Science, September 19, 2001
Thesis: Neural Network Models for Zebra Finch Song Production & Reinforcement Learning
Advisor: H. Sebastian Seung

Princeton University — Princeton, NJ
A.B., Physics, June 1, 1999
Minors: Biophysics, Engineering Physics, Applications of Computing, Applied & Computational Mathematics
Thesis: Topology and Dimensionality in Neural Network Memories
Advisor: John Hopfield

Appointments

Harvard University — Cambridge, MA
School of Engineering and Applied Sciences
Senior Research Fellow — Dec 2021–present
Lecturer — Jul 2021–present
Research Associate — Jul 2020–Nov 2021
Wyss Institute for Biologically Inspired Engineering
Senior Research Scientist — Nov 2014–Jun 2020
Staff Scientist—Bioinspired Robotics (Advanced Technology Team) — Jun 2009–Oct 2014

New England Complex Systems Institute — Cambridge, MA
Postdoctoral Fellow — Sept 2007–May 2009

Harvard Medical School/Children's Hospital Boston — Boston, MA
Research Fellow — Sept 2007–May 2009

Harvard University, Electrical Engineering & Computer Science — Cambridge, MA
Postdoctoral Fellow — Jul 2006–Aug 2007

MIT, Computer Science & Artificial Intelligence Laboratory — Cambridge, MA
Research Affiliate — Jun 2006–Jun 2012

Publications

Journals (refereed)

Kwon, Junghan, David Bombara, Clark Teeple, Joonhaeng Lee, Chuck Hoberman, Robert Wood, and Justin Werfel. Transformable linkage-based gripper for multi-mode grasping and manipulation. *IEEE Robotics and Automation Letters* **8**(12): 8446–8453 (2023).

Joshi, Varun, Stefan Popp, Justin Werfel, and Helen McCreery. Alignment with neighbors enables escape from dead ends in flocking models. *Journal of the Royal Society Interface* **19**: 20220356 (2022).

Graule, Moritz A., Thomas P. McCarthy, Clark B. Teeple, Justin Werfel, and Robert J. Wood. SoMoGym: A toolkit for developing and evaluating controllers and reinforcement learning algorithms for soft robots. *Robotics and Automation Letters* **7**(2): 4071 (2022).

Carey, Nicole E., Paul Bardunias, Radhika Nagpal, and Justin Werfel. Validating a termite-inspired construction coordination mechanism using an autonomous robot. *Frontiers in Robotics and AI* **8**: 645728 (2021).

Melenbrink, Nathan, Katja Rinderspacher, Achim Menges, and Justin Werfel. Autonomous anchoring for robotic construction. *Automation in Construction* **120**: 103391 (2020).

Bardunias, Paul, Daniel S. Calovi, Nicole Carey, Rupert Soar, J. Scott Turner, Radhika Nagpal, and Justin Werfel. The extension of internal humidity levels beyond the soil surface facilitates mound expansion in Macrotermes. *Proceedings of the Royal Society B* **287**: 20200894 (2020).

Melenbrink, Nathan, Justin Werfel, and Achim Menges. On-site autonomous construction robots: towards unsupervised building. *Automation in Construction* **119**: 103312 (2020).

Gershenson, Carlos, Vito Trianni, Justin Werfel, and Hiroki Sayama. Self-organization and artificial life. *Artificial Life* **26**(3): 391–408 (2020).

Carey, Nicole E., Daniel S. Calovi, Paul M. Bardunias, J. Scott Turner, Radhika Nagpal, and Justin Werfel. Differential construction response to humidity by related species of mound-building termites. *Journal of Experimental Biology* **222**: jeb212274 (2019).

Amir, Yaniv, Almogit Abu-Horowitz, Justin Werfel, and Ido Bachelet. Nanoscale robots exhibiting quorum sensing. *Artificial Life* **25**: 227–231 (2019).

Calovi, Daniel S., Paul Bardunias, Nicole Carey, J. Scott Turner, Radhika Nagpal, and Justin Werfel. Surface curvature guides early construction activity in mound-building termites. *Philosophical Transactions of the Royal Society B* **374**(1774): 20180374 (2019).

Melenbrink, Nathan, and Justin Werfel. Local force cues for strength and stability in a distributed robotic construction system. *Swarm Intelligence* **12**(2): 129–153 (2018).

Green, Ben, Paul Bardunias, J. Scott Turner, Radhika Nagpal, and Justin Werfel. Excavation and aggregation as organizing factors in de novo construction by mound-building termites. *Proceedings of the Royal Society B* **284**(1856): 20162730 (2017).

Werfel, Justin, Donald E. Ingber, and Yaneer Bar-Yam. Theory and associated phenomenology for intrinsic mortality arising from natural selection. *PLoS ONE* **12**(3): e0173677 (2017).

Werfel, Justin, Donald E. Ingber, and Yaneer Bar-Yam. Programmed death is favored by natural selection in spatial systems. *Physical Review Letters* **114**: 238103 (2015).

Grun, Casey, Justin Werfel, David Yu Zhang, and Peng Yin. DyNAMiC Workbench: an integrated development environment for dynamic DNA nanotechnology. *Journal of the Royal Society Interface* **12**: 20150580 (2015).

Petersen, Kirstin, Paul Bardunias, Nils Napp, Justin Werfel, Radhika Nagpal, and J. Scott Turner. Arrestant property of recently manipulated soil on *Macrotermes michaelseni* as determined through visual tracking and automatic labeling of individual termite behaviors. *Behavioural Processes* **116**: 8–11 (2015).

Werfel, Justin, Kirstin Petersen, and Radhika Nagpal. Designing collective behavior in a

termite-inspired robot construction team. *Science* **343**: 754–758 (2014).

Rutherford, A., D. Harmon, J. Werfel, A. S. Gard-Murray, S. Bar-Yam, A. Gros, R. Xulvi-Brunet, and Y. Bar-Yam. Good fences: the importance of setting boundaries for peaceful coexistence. *PLoS ONE* **9**(5): e95660 (2014).

Werfel, J., S. Krause, A. G. Bischof, R. J. Mannix, H. Tobin, Y. Bar-Yam, R. M. Bellin, and D. E. Ingber. How changes in extracellular matrix mechanics and gene expression variability might combine to drive cancer progression. *PLoS ONE* **8**(10): e76122 (2013).

Wade, M. J., D. S. Wilson, C. Goodnight, D. Taylor, Y. Bar-Yam, M. A. M. de Aguiar, B. Stacey, J. Werfel, G. A. Hoelzer, E. D. Brodie III, P. Fields, F. Breden, T. A. Linksvayer, J. A. Fletcher, P. J. Richerson, J. D. Bever, J. D. Van Dyken, and P. Zee. Multilevel and kin selection in a connected world. *Nature* **463**: E8–E9 (2010).

Werfel, Justin, and Radhika Nagpal. Three-dimensional construction with mobile robots and modular blocks. *International Journal of Robotics Research* **27**(3–4): 463–479 (2008).

Werfel, Justin, and Radhika Nagpal. Extended stigmergy in collective construction. *IEEE Intelligent Systems* **21**(2): 20–28 (2006).

Werfel, Justin, Xiaohui Xie, and H. Sebastian Seung. Learning curves for stochastic gradient descent in linear feedforward networks. *Neural Computation* **17**(12): 2699–2718 (2005).

Werfel, Justin, and Yaneer Bar-Yam. The evolution of reproductive restraint through social communication. *PNAS* **101**(30):11019–11024 (2004).

Mensh, Brett, Justin Werfel, and H. Sebastian Seung. BCI Competition 2003—data set Ia: combining gamma-band power with slow cortical potentials to improve single-trial classification of electroencephalographic signals. *IEEE Transactions on Biomedical Engineering* **51**(6):1052–1056 (2004).

Niebur, Ernst, et al. Research, robots, and reality: a statement on current trends in biorobotics. *Behavioral and Brain Sciences* **24**(6):1072–1073 (2001).

Werfel, Justin, Melanie Mitchell, and James P. Crutchfield. Effects of coevolution and resource sharing on the evolution of cellular automata. *IEEE Transactions on Evolutionary Computation* **4**(4): 388–393 (2000).

Conferences (refereed)

Carey, Nicole E., and Justin Werfel. A force-mediated controller for cooperative object manipulation with independent autonomous robots. In *Proceedings of Distributed Autonomous Robotic Systems 16* (DARS 2022), Montbéliard, France (2022).

Melenbrink, Nathan, Clark Teeple, and Justin Werfel. A robot factors approach to designing modular hardware. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS 2022), Kyoto, Japan (2022).

Teeple, Clark B., Justin Werfel, and Robert J. Wood. Multi-dimensional compliance of soft grippers enables gentle interaction with thin, flexible objects. In *Proc. IEEE International Conference on Robotics and Automation* (ICRA 2022), Philadelphia, PA (2022).

Melenbrink, Nathan, Ariel Wang, and Justin Werfel. An autonomous vault-building robot system for creating spanning structures. In *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA 2021), Xi'an, China (2021).

Carey, Nicole, and Justin Werfel. Collective transport of unconstrained objects via implicit coordination and adaptive compliance. In *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA 2021), Xi'an, China (2021).

Melenbrink, Nathan, and Justin Werfel. Autonomous sheet pile driving robots for soil stabilization. In *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA 2019), Montreal, Canada (2019).

Gershenson, Carlos, Vito Trianni, Justin Werfel, and Hiroki Sayama. Self-organization and artificial life: a review. In *Proceedings of the 2018 Conference on Artificial Life* (ALIFE

2018), Tokyo, Japan (2018).

Melenbrink, Nathan, Paul Kassabian, Achim Menges, and Justin Werfel. Towards force-aware robot collectives for on-site construction. In *Proceedings of the 2017 Association for Computer Aided Design in Architecture Conference* (ACADIA 2017), Cambridge, Massachusetts, pp. 382–391 (2017).

Melenbrink, Nathan, Panagiotis Michalatos, Paul Kassabian, and Justin Werfel. Using local force measurements to guide construction by distributed climbing robots. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS 2017), Vancouver, Canada, pp. 4333–4340 (2017).

Carey, Nicole, Radhika Nagpal, and Justin Werfel. Fast, accurate, small-scale 3D scene capture using a low-cost depth sensor. In *Proc. IEEE Winter Conference on Applications of Computer Vision* (WACV 2017), Santa Rosa, California, pp. 1268–1276 (2017).

Rubenstein, Michael, Bo Cimino, Radhika Nagpal, and Justin Werfel. AERobot: an affordable one-robot-per-student system for early robotics education. In *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA 2015), Seattle, Washington, pp. 6107–6113 (2015).

Becker, Aaron, Golnaz Habibi, Justin Werfel, Michael Rubenstein, and James McLurkin. Massive uniform manipulation: controlling large populations of simple robots with a common input signal. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS 2013), Tokyo, Japan, pp. 520–527 (2013).

Rubenstein, Michael, Adrian Cabrera, Justin Werfel, Golnaz Habibi, James McLurkin, and Radhika Nagpal. Collective transport of complex objects by simple robots: theory and experiments. In *Proceedings of the 12th International Conference on Autonomous Agents and Multiagent Systems* (AAMAS2013), Saint Paul, Minnesota, USA (2013).

Petersen, Kirstin, Radhika Nagpal, and Justin Werfel. TERMES: an autonomous robotic system for three-dimensional collective construction. In *Proceedings of Robotics: Science and Systems VII* (RSS 2011), Los Angeles, California (2011).

Werfel, Justin. Biologically inspired primitives for engineered morphogenesis. In *Proceedings of the 7th International Conference on Swarm Intelligence* (ANTS 2010), Brussels, Belgium, pp. 131–142 (2010).

Bailis, Peter, Radhika Nagpal, and Justin Werfel. Positional communication and private information in honeybee foraging models. In *Proceedings of the 7th International Conference on Swarm Intelligence* (ANTS 2010), Brussels, Belgium, pp. 263–274 (2010). **Winner of Best Student Paper Award; nominated for Best Paper Award.**

Yu, Chih-Han, Justin Werfel, and Radhika Nagpal. Collective decision-making in multi-agent systems by implicit leadership. In *Proceedings of the 9th International Conference on Autonomous Agents and Multiagent Systems* (AAMAS-2010), Toronto, Canada, pp. 1189–1196 (2010).

Yu, Chih-Han, Justin Werfel, and Radhika Nagpal. Coordinating collective locomotion in an amorphous modular robot. In *Proceedings of the 2010 IEEE International Conference on Robotics and Automation* (ICRA2010), Anchorage, Alaska, pp. 2777–2784 (2010).

Werfel, Justin, Donald Ingber, and Radhika Nagpal. Collective construction of environmentally-adaptive structures. In *Proceedings of the 2007 IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS 2007), San Diego, California, pp. 2345–2352 (2007).

Werfel, Justin. Robot search in 3D swarm construction. In *Proceedings of the First IEEE International Conference on Self-Adaptive and Self-Organizing Systems* (SASO 2007), Cambridge, Massachusetts, pp. 363–366 (2007).

Werfel, Justin, Yaneer Bar-Yam, Daniela Rus, and Radhika Nagpal. Distributed construction

by mobile robots with enhanced building blocks. In *Proceedings of the 2006 IEEE International Conference on Robotics and Automation* (ICRA 2006), Orlando, Florida, pp. 2787–2794 (2006).

Werfel, Justin, Yaneer Bar-Yam, and Radhika Nagpal. Building patterned structures with robot swarms. In *Proceedings of the Nineteenth International Joint Conference on Artificial Intelligence* (IJCAI 2005), Scotland, UK, pp. 1495–1502 (2005).

Werfel, Justin. Building blocks for multi-agent construction. In *Distributed Autonomous Robotic Systems* 6 (DARS 2004), Toulouse, France (2007).

Werfel, Justin, Xiaohui Xie, and H. Sebastian Seung. Learning curves for stochastic gradient descent in linear feedforward networks. In *Advances in Neural Information Processing Systems 16* (NIPS 2003), Vancouver, Canada, pp. 1197–1204 (2004).

Workshops (refereed)

Werfel, Justin. Embodied teachable agents: learning by teaching robots. New Research Frontiers for Intelligent Autonomous Systems, at 13th International Conference on Intelligent Autonomous Systems (IAS-13), Venice, Italy (2014).

Petersen, Kirstin, Nils Napp, Jao-ke Chin-Lee, Justin Werfel, and Radhika Nagpal. 3D tracking of building processes in Macrotermes. Workshop on Visual Observation and Analysis of Animal and Insect Behavior, at 21st International Conference on Pattern Recognition (ICPR 2012), Tsukuba, Japan (2012).

Werfel, Justin, Kirstin Petersen, and Radhika Nagpal. Distributed multi-robot algorithms for the TERMES 3D collective construction system. Workshop on Reconfigurable Modular Robotics, at IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS11), San Francisco, CA (2011).

Werfel, Justin, Yaneer Bar-Yam, and Donald Ingber. Bioinspired environmental coordination in spatial computing systems. Workshop on Spatial Computing, at Second IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO 2008), Venice, Italy, pp. 338–343 (2008).

Werfel, Justin, and Radhika Nagpal. Towards a common comparison framework for global-to-local programming of self-assembling robotic systems. Workshop on Self-Reconfigurable Robots & Systems and Applications, at IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2007), San Diego, CA (2007).

Werfel, Justin, and Radhika Nagpal. Three-dimensional directed construction. Workshop on Self-Reconfigurable Modular Robots, at Robotics: Science and Systems II, Philadelphia, PA (2006).

Schuil, Crystal, Matthew Valente, Justin Werfel, and Radhika Nagpal. Collective construction using LEGO robots. In *Proceedings of the Twenty-First National Conference on Artificial Intelligence* (AAAI 2006), Boston, MA (2006). Received Technical Innovation Award for "elegant connection of theory and design."

Technical Reports

Werfel, Justin. Anthills built to order: Automating construction with artificial swarms. Ph.D. thesis, Massachusetts Institute of Technology, Cambridge, MA; CSAIL Technical Report MIT-CSAIL-TR-2006-052 (2006).

Rutherford, Alex, Dion Harmon, Justin Werfel, Shlomiya Bar-Yam, Alexander Gard-Murray, Andreas Gros, and Yaneer Bar-Yam. Good fences: the importance of setting boundaries for peaceful coexistence. arXiv:1110.1409 (2011).

Werfel, Justin, and Yaneer Bar-Yam. Modeling, communication, and global catastrophe. *Knowledge Magazine* **1**(1):5–13 (2009).

Werfel, Justin, and Radhika Nagpal. Towards a common comparison framework for global-to-local programming of self-assembling robotic systems. Harvard Computer Science Technical Report TR-14-07 (2007).

Werfel, Justin, Yaneer Bar-Yam, and Radhika Nagpal. Construction by robot swarms using extended stigmergy. AI Memo AIM-2005-011, MIT Computer Science and Artificial Intelligence Lab (2005).

Werfel, Justin. Implementing universal computation in an evolutionary system. AI Memo AIM-2002-010, MIT Artificial Intelligence Lab (2002).

Werfel, Justin. Neural network models for zebra finch song production and reinforcement learning. Master's thesis, Massachusetts Institute of Technology, Cambridge, MA; AI Technical Report AITR-2004-008 (2001).

Invited Book Chapters

Melenbrink, Nathan, and Justin Werfel. A swarm robot ecosystem for autonomous construction, 2017. In *Robotic Building: Architecture in the Age of Automation,* Gilles Retsin, Manuel Jimenez, Mollie Claypool, and Vicente Soler, eds., München: DETAIL, pp. 88–90 (2019).

Werfel, Justin, and Paul Kassabian. Toward automating construction with decentralized climbing robots and environmentally adaptive, functionally specified structures. In *Active Matter*, Skylar Tibbits, ed., MIT Press, pp. 4333–4340 (2017).

Rutherford, Alex, May Lim, Richard Metzler, Dion Harmon, Justin Werfel, Shlomiya Bar-Yam, Alexander Gard-Murray, Andreas Gros, and Yaneer Bar-Yam. The geography of ethnic violence. In *Conflict and Complexity*, Philip Vos Fellman, Yaneer Bar-Yam, and Ali Minai, eds., Springer, pp. 235–248 (2015).

Werfel, Justin. Collective construction with robot swarms. In *Morphogenetic Engineering*, Rene Doursat, Hiroki Sayama, and Olivier Michel, eds., Springer, pp. 115–140 (2012).

Werfel, Justin. The ecology of Fraggle Rock. In *The Wider Worlds of Jim Henson*, Jennifer Garlen and Anissa Graham, eds., McFarland, pp. 62–72 (2013).

Grants

NASA STRI, "Resilient ExtraTerrestrial Habitats". PI: Shirley Dyke; lead co-PIs: Justin Werfel, Karen Marais, James Braun, Ramesh Malla; co-Is: Ilias Bilionis, Antonio Bobet, David Cappelleri, George Chiu, Ashwin Dani, Elena Glassman, Song Han, Chuck Hoberman, Mohammad Jahanshahi, Arturo Montoya, Krishna Pattipati, Julio Ramirez, Jiong Tan, Dawn Whitaker, Robert Wood. $15,000,000, September 2019–August 2024.

NIH R01, "Modeling individual-to-collective behavior in mound-building termites". PI: Justin Werfel; co-PIs: Radhika Nagpal, J. Scott Turner. $1,859,193, September 2014–August 2019.

DARPA Seedling, "Engineering self-organizing systems: theory and topdown synthesis methodology for resilient collectives using Kilobot and molecular robotics platforms". PI: Radhika Nagpal; co-PIs: Justin Werfel, Peng Yin. $650,000, January 2017–January 2019.

Wyss Institute Director's Challenge Cross-Platform Grant, "Metamorpho: a robotic platform for emulating the developmental induction of locomotor patterns". PIs: Eugene Goldfield, Radhika Nagpal, James Niemi, Justin Werfel. $75,000, July 2014–June 2015.

Patents

Melenbrink, Eric Nathaniel, and Justin Werfel. Self-contained soil stabilization system. U.S. Patent 11,499,287 (2022).

Dubrovsky, Zivthan, Raphael Cherney, Michael Mogenson, Justin Werfel, Kathleen O'Donnell, Radhika Nagpal, Nils Napp, Hani Sallum, and Julian da Silva Gillig. Color- or grayscale-sensing, magnetic, mobile, marking robot. U.S. Patent 10,086,516 (2018).

Invited Talks

WBUR (NPR), On Point, May 13, 2022
Autodesk Inc., April 27, 2022
Sainsbury Wellcome Center/Gatsby GCNU at University College London, Symposium on How Dumb Agents Act Clever Together, October 8, 2021
University of Melbourne, Bioinspiration Hallmark Research Initiative, August 26, 2020
Living Machines Conference, Workshop on Growing Structures: Bioinspired Innovation Insights for Architecture and Robotics, July 28, 2020
University of Michigan, Computer Science & Engineering Seminar, March 25, 2020
University of Michigan, Complex Systems Seminar, March 24, 2020
Toyota Technological Institute at Chicago, Colloquium, March 2, 2020
Cambridge Entomological Club, January 14, 2020
University of Connecticut, Electrical & Computer Engineering Colloquium, Nov. 13, 2019
TEDxPrincetonU, December 8, 2018
MIT, Global Community Bio Summit, October 26, 2018
Wyss International Symposium on Molecular Robotics, September 21, 2018
International Conference on Complex Systems, July 22–27, 2018
Conference on Collective Behavior, ICTP, Trieste, May 7–11, 2018
ICRA Workshop on Self-Healing, Growing and Evolving Soft Robots, May 21, 2018
Santa Fe Institute, March 21, 2018
University of New Mexico, March 19, 2018
TEDxBeaconStreet, November 18, 2017
Union College, Computer Science Seminar and Biology Seminar, March 2, 2017
Australian National University, Biology Seminar, December 14, 2016
University of Technology Sydney, Faculty of Engineering and Information Technology Seminar, December 8, 2016
International Congress of Entomology, Symposium on Excavation and Construction by Social Insects, September 29, 2016
American Physical Society March Meeting, March 18, 2016
Technical University of Denmark, February 5, 2016
IT University of Copenhagen, February 4, 2016
Complex Systems Digital Campus World e-Conference, September 30–October 1, 2015
Keynote talk, 13th European Conference on Artificial Life (ECAL 2015), July 20–24, 2015
University of Sheffield, Automatic Control & Systems Engineering Seminar, July 17, 2015
O'Reilly Solid, June 23–25, 2015
Wellesley College, Physics and Engineering Seminar, May 4, 2015
Keynote talk, 8th International Conference on Bio-inspired Information and Communications Technologies (BICT/BIONETICS), December 1–3, 2014
Georgia Tech, Institute for Robotics and Intelligent Machines Seminar, October 29, 2014
Keynote talk, Workshop on Modular and Swarm Systems—From Nature to Robotics, at IEEE/RSJ International Conference on Intelligent Robots and Systems, Sept. 14, 2014
University of Colorado Boulder, Computer Science Symposium, June 27, 2013
Future Global Leaders Program, 2012–2014
Queensland University of Technology, December 6, 2011
University of Queensland, Queensland Brain Institute, December 5, 2011
Future of Robotics Summit, Mass Technology Leadership Council, December 2, 2011
Toyota Technological Institute at Chicago, Colloquium, October 24, 2011
Northwestern University, Mechanical Engineering Seminar, October 24, 2011
University of Pennsylvania, GRASP Seminar, September 9, 2011
Harvard Museum of Natural History, March 5, 2011

Northeastern University, January 27, 2011
iRobot Corporation, October 4, 2010
Vrije Universiteit Amsterdam, Artificial Intelligence Seminar, September 13, 2010
Keynote talk, 3rd International Workshop on Guided Self-Organization, Indiana University, September 4–6, 2010
University of Maryland, Computer Science Colloquium, April 9, 2009
Columbia University, Electrical Engineering Seminar, March 26, 2009
Indiana University, School of Informatics Colloquium, March 5, 2009
Rice University, Computer Science Colloquium, February 12, 2009
Vanderbilt University, Electrical Engineering & Computer Science, February 5, 2009
Grey Thumb Boston, February 2, 2009
Brown University, Computer Science Department Seminar, November 3, 2008
University of Massachusetts Amherst, Computer Science Department Seminar, Jan. 29, 2008
Dartmouth University, Neukom Institute, June 11, 2007
Charles River Associates, May 25, 2007
Brandeis University, Computer Science Colloquium, March 29, 2007
Princeton University, Computer Science Graphics/Media series, October 9, 2006
International Conference on Complex Systems, June 27, 2006
Sandia National Laboratories, March 14, 2006
Icosystem Corporation, December 9, 2005
University of Vermont, Computer Science Seminar, December 5, 2005
University of Vermont, Biological Complexity Seminar, December 5, 2005
MIT CSAIL Student Seminar, November 28, 2005
MIT CSAIL Dangerous Ideas Seminar, March 31, 2005
International Conference on Complex Systems, May 18, 2004
MIT EECS Masterworks Forum, April 30, 2001

Other Professional Activities

Affiliate Faculty, Kempner Institute for the Study of Natural & Artificial Intelligence at Harvard University, 2023–present.
Doctoral thesis examiner for Moritz Graule (Harvard University), 2023; Jordan Kennedy (Harvard University), 2022; Nathan Melenbrink (University of Stuttgart), 2021; Ed Bray (University of Sheffield), 2023; Juncheng Li (Purdue University), 2024; Moises Pacheco (Technical University of Denmark), 2016; Anh Tuan Phan (Monash University), 2012.
General Chair (with Julien Bourgeois and Jamie Paik) of 16th International Symposium on Distributed Autonomous Robotic Systems (DARS 2022), November 28–30, 2022.
Steering Committee member of The International Association for Guided Self-Organization, 2015–2024.
Advisory Board member of IEEE Robotics & Automation Society—Special Interest Group on Humanitarian Technology (RAS–SIGHT), 2020–present.
Honorary Associate of the University of Sydney, School of Civil Engineering, Faculty of Engineering and Information Technologies, 2015–2017.
Organizer (with Kirstin Petersen and Mike Rubenstein) of Swarms: From Biology to Robotics and Back workshop at IEEE International Conference on Robotics and Automation (ICRA2018), Brisbane, Australia, May 21–25, 2018.
Co-organizer (with Helen McCreery) of track in Collective Behavior and Emergent Phenomena in Biology workshop at Mathematical Biosciences Institute, The Ohio State University, Columbus, Ohio, September 10–12, 2018.
Chair (with Radhika Nagpal and Chih-Han Yu) of Multi-Robot Teaming Challenge at

International Joint Conference on Artificial Intelligence (IJCAI-09), Pasadena, California, July 13–16, 2009.

Chair (with Marco Mamei) of tracks on Self-Organization in Pervasive Distributed Systems (SOPDS 2008, 2009) at ACM Symposiums on Applied Computing: ACM SAC 2008, Fortaleza, Brazil, March 16–20, 2008; and ACM SAC 2009, Honolulu, Hawaii, March 8–12, 2009.

Organizer (with Jake Beal, Jonathan Bachrach, Olivier Michel, and Dan Yamins) of Spatial Computing Workshop at Second IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO 2008), Venice, Italy, October 20, 2008.

Editorial Board member for special issue of Swarm Intelligence journal on Swarm Robotics (**2**(2–4), December 2008).

Program Committee member for Robotics: Science and Systems (RSS 2012, 2018, 2021), Distributed Autonomous Robotic Systems (DARS 2008, 2010, 2016, 2018, 2020, 2024), International Conference on Swarm Intelligence (ANTS 2010, 2014, 2016, 2018, 2020, 2022), International Symposium on Stabilization, Safety, and Security of Distributed Systems (SSS 2010), International Conference on Complex Systems (ICCS 2011, 2018), Genetic and Evolutionary Computation Conference (GECCO 2011, 2012, 2013, 2014), IEEE Symposium on Artificial Life (at IEEE SSCI 2011, 2013, 2015, 2017, 2019, 2020), International Conference on Artificial Life (ALIFE 2018, 2021), Conference on the Synthesis and Simulation of Living Systems (ALIFE 2014, 2016), European Conference on Artificial Life (ECAL 2015, 2017), Bio-inspired Information and Communication Technologies (BICT 2017), International Conference on Guided Self-Organization (GSO 2016, 2018, 2022), Northeast Regional Conference on Complex Systems (NERCCS 2018, 2020), Workshop on Self-Organizing Construction (at IEEE SASO 2016, 2018, 2019), Morphogenetic Engineering Workshop (MEW 2015), Swarm Robotics track at Bio-inspired Information and Communications Technologies (BICT 2015), AAAI Robotics Fellowship (AAAI-15-RF), posters at IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO 2009).

Reviewer for Science, Science Robotics, Nature Communications, Nature Machine Intelligence, IEEE Transactions on Robotics, International Journal of Robotics Research, Soft Robotics, Autonomous Robots, Swarm Intelligence, Robotics and Autonomous Systems, Automation in Construction, Artificial Life, PLOS Computational Biology, ACM Transactions on Autonomous and Adaptive Systems, IEEE Robotics and Automation Letters; IEEE International Conference on Robotics and Automation (ICRA 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2018, 2019, 2021, 2022, 2023), IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2020, 2021, 2022), IEEE International Conference on Soft Robotics (RoboSoft 2020), International Symposium on Multi-Robot and Multi-Agent Systems (MRS 2021), IEEE Conference on Automation Science and Engineering (CASE 2010), International Conference on DNA Computing and Molecular Programming (DNA19); Army Research Office, National Science Foundation.

Invited panelist at 2018 International Workshop on Resilient ExtraTerrestrial Habitats, October 22–23, 2018, Purdue University, West Lafayette, Indiana.

Invitee to Radcliffe Institute workshop “Programmable Molecular Robots and Nanobots: An Exploration of Possible Futures” (organized by Gal Kaminka and George Church), September 7–9, 2014, Cambridge, Massachusetts.

Invitee to National Evolutionary Synthesis Center’s catalysis meeting “Evolution of Insect Sociality: An Integrative Modeling Approach”, October 14–17, 2010, Durham, NC.

Participant in Telluride Neuromorphic Engineering Workshop, July 1–21, 2001, Telluride, Colorado.
Participant in Methods in Computational Neuroscience course at Marine Biological Laboratory, August 2000, Woods Hole, Massachusetts.

Teaching

Introduction to Robotics / Advanced Introduction to Robotics (Harvard ES 159 / ES 259 / SCI 6274) course head, fall 2021, fall 2022, fall 2023.
Engineering Design Projects (Harvard ES 100; senior thesis/capstone design project) advisor, 2022–present.
Informal Robotics / New Paradigms for Design and Construction (Harvard SCI 6478) juror, 2015–present.
Harvard Board of First-Year Advisers, 2022–2023.
Lecturer for New England Complex Systems Institute biannual short courses on complexity, 2004–2020.
Supervisor for research (undergraduate, graduate, postdoctoral, staff) at Harvard (2005–2007, 2009–present) and NECSI (2004–2009).
Introduction to Electrical Engineering and Computer Science (MIT 6.01) development & pilot TA, fall 2005, spring 2006.
Introduction to Computational Neuroscience (MIT 9.29) TA, spring 2003, spring 2004.
Created curriculum for national STEM summer camp i2 Camp, "BugBots: Programming Mini-Robots", introduction to programming and robotics for 5^{th}–8^{th} grades, 2014.
Designed and taught MIT Athletics Department juggling class, January 2005; Open Air Circus classes in unicycling, diabolo, and devil sticks, summer 2004; pantomime classes at MIT (2004) and Harvard (2011, 2012).

Honors and Awards

2023 ISAL (International Society for Artificial Life) Award for Outstanding Reviewer / Best Reviewer Award, Artificial Life Journal, 2023.
Department of Defense National Defense Science & Engineering Graduate Fellowship, 1999.
National Science Foundation Graduate Research Fellowship (declined), 1999.
Fannie and John Hertz Foundation Finalist, 1999.
Kusaka Memorial Prize in Physics, Princeton University, 1999.
Phi Beta Kappa, 1999.
MIT Arts Scholar, 2004–2006.

Professional and Honor Societies

Sigma Xi, 1999–present.
IEEE / Robotics & Automation Society, 2005–present.
AAAI, 2006–2007.
American Physical Society, 2015–2016.

Work-Life Balancing

Storytelling (The Moth [multiple StorySLAM Winner], Story Collider, Massmouth [PBS feature, multiple judge and audience awards at annual final competitions]); fiction writing (Full member of the SFWA); glassblowing (MIT Glass Lab, Haystack); puzzles (crossword construction [New York Times, Los Angeles Times, Wall Street Journal, Andrews McMeel Universal], MIT Mystery Hunt, National Puzzlers' League); juggling (Princeton, MIT, Harvard Juggling Clubs); pantomime (MIT MIMEtype, Princeton Movement Theatre, First Night Boston); theater (Princeton Triangle Club, Theatre@First); a cappella (MIT Techiya); MIT GSC (Edgerton House, Graduate Ring Committee); cycling (bi- and uni-); archery; fencing (sabre); skiing; diving; hiking; music (Princeton University Band; piano, ukulele, saw).