Dr. Theodore P. Pavlic, Curriculum Vitae (abbreviated)

Associate Professor (with tenure), Arizona State University School of Computing and Augmented Intelligence (tenure home) – 75% School of Life Sciences – 25%

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Pavlic leads the Science and Engineering of Autonomous Decision-Making Systems (SEADS) lab at Arizona State University (ASU). The laboratory takes an interdisciplinary approach to understanding how natural and artificial complex adaptive systems perceive their environment and make effective decisions autonomously. There is equal focus in the SEADS lab on discovery and scientific inference as there is on technological design and engineering. Lab members from a variety of different backgrounds: (a) conduct empirical lab and field behavioral research with living systems (e.g., ant colonies); (b) develop mathematical (theoretical) models of natural cognitive phenomena; (c) design and implement beyond state-of-the-art computational tools for understanding socio-ecological systems; and (d) develop bio-inspired distributed algorithms for decentralized control of engineered systems in the built environment. Methods that are particularly well represented in the SEADS lab come from optimization, distributed algorithms, artificial intelligence/machine learning, behavioral ecology, cognitive psychology, and bio-inspired algorithmic design. Target application areas include collective intelligence, the built environment, multi-robot systems, and human—computer augmented intelligence.

CURRENT ACADEMIC APPOINTMENTS

Associate Professor (with tenure), Arizona State University......August 2022 to December 2022

Assistant Professor, Arizona State University.....August 2015 to July 2022

School of Computing and Augmented Intelligence (50%, tenure home)

School of Sustainability (25%)

School of Complex Adaptive Systems (25%)

Affiliations at ASU (2015–present):

- The Biomimicry Center at ASU (Associate Director of Research)
- ASU–Sante Fe Institute Global Center for Biosocial Complex Systems (ASU–SFI Fellow)
- BEYOND Center for Fundamental Concepts in Science
- Center for Social Dynamics and Complexity (CSDC)
- Center for Biodiversity Outcomes (CBO)
- Center for Human, AI, and Robot Teaming (CHART)
- Center for Biocomputation, Security, and Society (CBSS)

External Faculty, Human Computation Institute................................June 2015 to present

PREVIOUS ACADEMIC APPOINTMENTS

Associate Research Scientist (Behavioral Ecology), Arizona State UniversityAugust 2014 to July 2015 School of Life Sciences [host: Dr. Stephen C. Pratt]

- Affiliations:
 - o School of Computing, Informatics, and Decision Systems Engineering
 - BEYOND Center for Fundamental Concepts in Science

Center for Social Dynamics and Complexity

Postdoctoral Scholar (Behavioral Ecology), Arizona State University......July 2012 to August 2014 School of Life Sciences

Supervisors: Stephen C. Pratt, Robert E. Page

Postdoctoral Researcher (Computer Science), The Ohio State University September 2010 to June 2012 Department of Computer Science and Engineering

- Supported by NSF ECS-0931669: "Autonomous Driving in Mixed-Traffic Urban Environments"
 - o Supervisor (co-PI): Paolo A.G. Sivilotti [PI: Ümit Özgüner]

EDUCATION

The Ohio State University, Columbus, OH

Ph.D., Electrical and Computer Engineering, August 2010

- Dissertation Topic: Design and Analysis of Optimal Task-Processing Agents
- Advisor: Professor Kevin M. Passino
- Area of Study: Control Engineering / Minor: Behavioral Ecology and Animal Behavior

M.S, Electrical and Computer Engineering, August 2007

- Thesis Topic: Optimal Foraging Theory Revisited
- Advisor: Professor Kevin M. Passino
- Area of Study: Control Engineering

B.S.E.C.E., Electrical and Computer Engineering, June 2004

- Magna cum Laude, with Honors in Engineering
- Electrical specialization (emphasis on electromagnetics and digital computers)
- Minor in Computer and Information Systems (programming and algorithms track)

SELECTED SPONSORED PROJECTS

- "EFRI BRAID: Principles of sleep-dependent memory consolidation for adaptive and continual learning in artificial intelligence", NSF, \$815,846 (subaward total from UCSD to ASU), 2022–2026 [subaward PI]
- "Autonomous System Control via Social Insect Models Phase II (ASC-SIM II)", Air Force Special Operations Command, \$663,487 (subaward total from Boston Fusion Corp to ASU), 2022–2024 [subaward co-I]
- "EAGER: Embodiment of Human Values Profiles in Autonomous Vehicles via Psychomimetic Controller Design", NSF, \$300,000, 2021–2024 [co-I]
- "Designing nature to enhance resilience of built infrastructure in western US land", US Army Corps of Engineers, \$4,499,990, 2021–2024 [co-I]
- "Distributed Swarm Control (DiSCo)", Boston Fusion Corporation, \$49,999, 2021 [PI]
- "Energy-efficient Neuromorphic Computing in Light of the Structural and Functional Evolution of Multiscale Insect Brains", DARPA DSO, \$1,000,000, 2019–2022 [co-I]
- "Biomimicry for Sensory Communication", Google Inc., \$288,367, 2017–2018 [co-I]
- "BioSwarm: Bio-Inspired Swarming", DARPA I2O, \$193,079 (subaward total from GTRI to ASU), 2017—2018 [co-I]
- "CRISP: Type 2/Collaborative Research: Design and Control of Coordinated Green and Gray Water Infrastructure to Improve Resiliency in Chemical and Agricultural Sectors", NSF, \$1,874,988, 2017–2021 [co-I]
- "Emergent Computation in Collective Decision Making by the Crevice-Dwelling Rock Ant *Temnothorax rugatulus*", NSF, \$934,062, 2016–2019 [co-I]

SELECTED JOURNAL PUBLICATIONS [REFEREED]

- Navas Zuloaga, M.G., K.M. Baudier, J.H. Fewell, N. Ben-Asher, T.P. Pavlic, and Y. Kang. A Modeling Framework for Adaptive Collective Defense: Crisis Response in Social-Insect Colonies. *Journal of Mathematical Biology* (IF=2.0), 87:87. doi:10.1007/s00285-023-01995-5
- Burchill, A.T., T.P. Pavlic, S.C. Pratt, and C.R. Reid. Weaver ants regulate the rate of prey delivery during collective vertical transport. *Journal of Experimental Biology* (IF=3.2), 226(19):jeb245634. doi:10.1242/jeb.245634
- Navas Zuloaga, M.G., T.P. Pavlic, and B.H. Smith. Alternative model systems for cognitive variation: eusocial-insect colonies. *Trends in Cognitive Sciences* (IF=15.4), 26(10):836–848. 2022. **Invited**. doi:10.1016/j.tics.2022.06.011
- Hunter, A.H., T.P. Pavlic, M.J. Angilletta Jr., R.S. Wilson. Identifying the best strategy for soccer penalty success: A predictive model for optimizing behavioural and biomechanical trade-offs. *Journal of Biomechanics* (IF=1.617), 141:111208. 2022. doi:10.1016/j.jbiomech.2022.111208
- Baudier, K.M., M.M. Bennett, M. Barrett, F.J. Cossio, R.D. Wu, S. O'Donnell, T.P. Pavlic, and J.H. Fewell. Soldier neural architecture is temporarily modality specialized but poorly predicted by repertoire size in the stingless bee *Tetragonisca angustula*. *Journal of Comparative Neurology* (IF=3.331), 530(4):672–682. 2022. doi:10.1002/cne.25273
- X. Guo, M.R. Lin, L.P. Saldyt, A. Azizi, Y. Kang, T.P. Pavlic, and J.H. Fewell. Decoding alarm signal propagation of seed-harvester ants using automated movement tracking and supervised machine learning. *Proceedings of the Royal Society B: Biological Sciences* (IF=4.637), 289:20212176. 2022. doi:10.1098/rspb.2021.2176
- Baudier, K.M., and T.P. Pavlic. Multi-Level Instrumentation of Bivouac Thermoregulation: Current Methods and Future Directions. *Artificial Life and Robotics* (IF=1.04), 27:308–315. 2022. doi:10.1007/s10015-022-00759-6
- Valentini, G, T.P. Pavlic, S.I. Walker, S.C. Pratt, D. Biro, and T. Sasaki. Naïve individuals promote collective exploration in homing pigeons. *eLife* (IF=7.080), 10:e68653. 2022. doi:10.7554/eLife.68653
- Caetano-Anollés, K., B. Ewers, S. Iyer, J.R. Lucas, T.P. Pavlic, A.P. Seale, and Y. Zeng. A minimal framework for describing living systems: a multi-dimensional view of life across scales. *Integrative and Comparative Biology* (IF=2.637), 61(6):2053–2065. 2021. **Authors in alphabetical order.** doi:10.1093/icb/icab172
- Pavlic, T.P., J. Hanson, G. Valentini, S.I. Walker, and S.C. Pratt. Quorum sensing without deliberation: Biological inspiration for externalizing computation to physical spaces in multi-robot systems. *Swarm Intelligence* (IF=2.556), 15(1):171–203. 2021. doi:10.1007/s11721-021-00196-4
- Baudier, K.M., and T.P. Pavlic. Incidental interactions among Neotropical army-ant colonies are met with self-organized walls of ants (Hymenoptera: Formicidae). *Myrmecological News* (IF=2.6, 15/111 in Entomology), 30:251–258. 2020. doi:10.25849/myrmecol.news 030:251
- Wheatley, R., T.P. Pavlic, O. Levy, and R.S. Wilson. Habitat features and performance interact to determine the outcomes of terrestrial predator—prey pursuits. *Journal of Animal Ecology* (IF=5.07), 89(12):2951–2971. 2020. doi:10.1111/1365-2656.13353
- Valentini, G., N. Mizumoto, S.C. Pratt, T.P. Pavlic, and S.I. Walker. Revealing the structure of information flows discriminates similar animal social behaviors. *eLife* (IF=7.080), 9:e55395. 2020. doi:10.7554/eLife.55395
- Baudier, K.M., M.M. Bennett, M.M. Ostwald, S. Hart, T.P. Pavlic, and J.H. Fewell. Age-based changes in kairomone response mediate task partitioning in stingless bee soldiers (*Tetragonisca angustula*). *Behavioral Ecology* (IF=3.347, 10/168 in Zoology), 74(10):1–9. 2020. doi:10.1007/s00265-020-02902-4
- Wilson, R.S., T.P. Pavlic, R. Wheatley, A.C. Niehaus, and O. Levy. Modeling escape success in terrestrial predator—prey interactions. *Integrative and Comparative Biology* (IF=2.637), 60(2):497–508. 2020. doi:10.1093/icb/icaa070

- Baudier, K.M., M. Ostwald, C. Grueter, F. Segers, D. Roubik, T.P. Pavlic, S. Pratt, and J. Fewell. Changing of the guard: flexible specialization and age polyethism in nest defense of the stingless bee *Tetragonisca angustula*. *Behavioral Ecology* (IF=3.347, 10/168 in Zoology), 30(4):1041–1049. 2019. doi:10.1093/beheco/arz047
- Burchill, A., and T.P Pavlic. Dude, Where's my Mark? Creating Robust Animal Identification Schemes Informed by Communication Theory. *Animal Behaviour* (IF=2.689), 154:203–208. 2019. doi:10.1016/j.anbehav.2019.05.013
- Pavlic, T.P., S. Wilson, G.P. Kumar, and S. Berman. Control of stochastic boundary coverage by multi-robot systems. *Journal of Dynamic Systems, Measurement, and Control* (IF=1.304), 137(3):034505, October 21, 2014. doi:10.1115/1.4028353
- Pavlic, T.P., and K.M. Passino. Distributed and Cooperative Task Processing: Cournot Oligopolies on a Graph. *IEEE Transactions on Cybernetics* (IF=11.079), 44(6):774–784, June 2014. doi:10.1109/TCYB.2013.2271776
- Pavlic, T.P., and K.M. Passino. Generalizing foraging theory for analysis and design. *The International Journal of Robotics Research* (IF=4.047), 30(5):505–523, 2011. doi:10.1177/0278364910396551
- Pavlic, T.P., and K.M. Passino. The sunk-cost effect as an optimal rate-maximizing behavior. *Acta Biotheoretica* (IF=0.950), 59(1):53–66, 2011. doi:10.1007/s10441-010-9107-8
- Pavlic, T.P., and K.M. Passino. When rate maximization is impulsive. *Behavioral Ecology and Sociobiology* (IF=2.382), 64(8):1255–1265, August 2010. doi:10.1007/s00265-010-0940-1
- Pavlic, T.P., and K.M. Passino. Foraging theory for autonomous vehicle speed choice. *Engineering Applications of Artificial Intelligence* (IF=4.201), 22(3):482–489, April 2009. doi:10.1016/j.engappai.2008.10.017

SELECTED CONFERENCE PUBLICATIONS [REFEREED]

- Hong, J., K.H. Park, and T.P. Pavlic. Concept-Centric Transformers: Enhancing Model Interpretability through Object-Centric Concept Learning within a Shared Global Workspace. In: *Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision (WACV 2024)*, January 4–8, 2024.
- Hong, J., and T.P. Pavlic. Randomly Weighted Neuromodulation in Neural Networks Facilitates Learning of Manifolds Common Across Tasks. In: *Proceedings of the 2023 Workshop on Unifying Representations in Neural Models (UniReps 2023 @ NeurIPS 2023)*, December 15, 2023. **Best UniReps Proceedings Paper Award.**
- Hong, J., and T.P. Pavlic. Representing Prior Knowledge Using Randomly, Weighted Feature Networks for Visual Relationship Detection. In: *Proceedings of the First International Workshop on Combining Learning and Reasoning: Programming Languages, Formalisms, and Representations (CLeaR 2022 @ AAAI-2022)*, February 28, 2022.
- Hong, J., and T.P. Pavlic. An Insect-Inspired Randomly Weighted Neural Network with Random Fourier Features for Neuro-Symbolic Relational Learning. In: *Proceedings of the 15th International Workshop on Neural-Symbolic Learning and Reasoning (NeSy '20/21 @ IJCLR 2021)*, October 25–27, 2021.
- Choi, T., B.P. Pyenson, J. Liebig, and T.P. Pavlic. Beyond Tracking: Using Deep Learning to Discover Novel Interactions in Biological Swarms. In: *Proceedings of the 4th International Symposium on Swarm Behavior and Bio-Inspired Robotics (SWARM-2021)*, June 1–4, 2021. Kyoto, Japan. **Best paper award.**
- Choi, T., B.P. Pyenson, J. Liebig, and T.P. Pavlic. Identification of Abnormal States in Videos of Ants Undergoing Social Phase Change. In: *Proceedings of the AAAI Conference on Artificial Intelligence (AAAI-21)*, 35(17):15286–15292, February 4–6, 2021. Virtual conference.
- Choi, T., and T.P. Pavlic. Automatic Discovery of Motion Patterns that Improve Learning Rate in Communication-Limited Multi-Robot Systems. In: *Proceedings of the 2020 IEEE Conference on Multisensor Fusion and Integration for Intelligent Systems (MFI 2020)*, September 14–16, 2020. Karlsruhe, Germany. doi:10.1109/MFI49285.2020.9235218

- Bowers, K.P., L.G. Strickland, G. Cooke, C. Pippin, and T.P. Pavlic. Trust-based Information Propagation on Multi-robot Teams in Noisy Low-communication Environments. In: *Proceedings of the 14th International Symposium on Distributed Autonomous Robotic Systems (DARS 2018; acceptance rate 36%)*, October 15–17, 2018. Boulder, CO, USA. doi:10.1007/978-3-030-05816-6 17
- Strickland, L.G., K. Baudier, K.P. Bowers, T.P. Pavlic, and C. Pippin. Bio-Inspired Role Allocation of Heterogeneous Teams in a Site Defense Task. In: *Proceedings of the 14th International Symposium on Distributed Autonomous Robotic Systems (DARS 2018; acceptance rate 42%)*, October 15–17, 2018. Boulder, CO, USA. doi:10.1007/978-3-030-05816-6_10
- Cooke, G., E. Squires, L. Strickland, K. Bowers, C. Pippin, T.P. Pavlic, and S.C. Pratt. Bio-inspired nest-site selection for distributing robots in low-communication environments. In: *Proceedings of the 16th International Conference on Practical Applications of Agents and Multi-Agent Systems (PAAMS 2018)*, June 20–22, 2018. Toledo, Spain. doi:10.1007/978-3-319-94779-2 44
- Pavlic, T.P., A. Adams, P.C.W. Davies, and S.I. Walker. Self-referencing cellular automata: A model of the evolution of information control in biological systems. In: *Proceedings of the 14th International Conference on the Synthesis and Simulation of Living Systems (ALIFE 14)*, July 30 August 2, 2014. New York, NY, USA. doi:10.7551/978-0-262-32621-6-ch083
- Pavlic, T.P. Using Physical Stigmergy in Decentralized Optimization Under Multiple Non-separable Constraints: Formal Methods and an Intelligent Lighting Example. In: *Proceedings of the 2014 Workshop on Nature Inspired Distributed Computing (NIDISC 2014 @ IPDPS 2014),* pp. 402–411, May 19, 2014. Phoenix, AZ, USA. doi:10.1109/IPDPSW.2014.52
- Pavlic, T.P., S. Wilson, G.P. Kumar, and S. Berman. An enzyme-inspired approach to stochastic allocation of robotic swarms around boundaries. In: *Proceedings of the 16th International Symposium on Robotics Research (ISRR 2013)*, pp. 631–647, December 16–19, 2013. Singapore. doi:10.1007/978-3-319-28872-7_36

SELECTED BOOK CHAPTERS

- Pavlic, T.P. Social Models from Non-Human Systems. In: P. Davis, J. Pfautz, and Angela O'Mahony (Eds), Social-Behavioral Modeling for Complex Systems, ch. 11, pp. 231–261. John Wiley & Sons, 2019. Invited book chapter. doi:10.1002/9781119485001.ch11
- Weinstein, S., and T.P. Pavlic. Noise and function. In: S.I. Walker, P.C.W. Davies, and G.F.R. Ellis (Eds), From Matter to Life: Information and Causality, ch. 9, pp. 126–143. Cambridge University Press, 2017. Invited book chapter. doi:10.1017/9781316584200.009
- Pavlic, T.P., and S.C. Pratt. Superorganismic Behavior via Human Computation. In: P. Michelucci (Ed.), *Handbook of Human Computation*, ch. 74, pp. 911–960. Springer, New York, NY, 2013. **Invited book chapter.** doi:10.1007/978-1-4614-8806-4_74

SELECTED INVITED PRESENTATIONS

- Pavlic, T.P. Technically a Model: Animal Behavior in Engineering Design. In: 58th Annual Conference of the Animal Behavior Society (ABS 2021), 2021. Invited Past-President Symposium speaker.
- Pavlic, T.P. Viewing the socio-technological dimensions of vehicle autonomy through the lens of ecology and organismal and integrative biology. In: *IPAM Workshop IV: Social Dynamics Beyond Vehicle Autonomy*, November 30 December 4, 2020. UCLA. **Invited speaker.**
- Pavlic, T.P. Thinking about Randomness for Thinking. In: *Google/O'Reilly Science Foo Camp (SciFoo 2020)*, October 23–25, 2020. **Invited speaker.**
- Pavlic, T.P. Cognition in Tiny, Random Spaces: What You Get for Free When There is No Free Energy. In: Soft Condensed Matter & Physics of Living Systems Seminar, March 10, 2020. Georgia Institute of Technology. Invited seminar speaker.

- Pavlic, T.P. Distributed algorithms in biological systems: The diverse architectures of natural computation. In: AMS Special Session on Emergent Phenomena in Discrete Models (2018 Joint Mathematics Meetings, JMM 2018), January 10–13, 2018. San Diego, CA, USA. Invited speaker.
- Pavlic, T.P. Thinking outside the 'bot: What ecology, physiology, and conservation biology can offer to engineering design. In: *Georgia Institute of Technology Decision and Control Laboratory Seminar*, July 19, 2017. Atlanta, GA, USA. **Invited seminar speaker.**
- Pavlic, T.P. Living laboratories and natural histories for distributed computing. In: *Moving and Computing* 2017: 7th Research Meeting and School on Distributed Computing by Mobile Robots, June 5–9, 2017. La Maddelena, Italy. **Invited speaker.**
- Pavlic, T.P. Be Undisciplined. Lose Your Innocence, Get to Work. In: *TEDxASU 2017: Innovators*, March 23, 2017. Tempe, AZ, USA. **Invited speaker.**
- Pavlic, T.P. From social insects to smart, flexible, adaptive teams of robots: The biomechanics of group decision-making. In: *Bioinspiration Crossing Disciplinary Borders (symposium of 2016 International Congress of Entomology, ICE 2016)*, September 25–30, Orlando, FL, USA. **Invited speaker.**

POSTDOCTORAL RESEARCHERS

Dr. Kaitlin Baudier, Ecology and Organismal Biology, 2017–2021 [now Asst Prof, U. of S. Mississippi] Dr. Gabriele Valentini, Swarm Intelligence, 2016–2019 [now Data Scientist at Adaptify, Amsterdam]

FORMER (GRADUATED) STUDENT MENTEES [ADVISING CHAIR or CO-CHAIR]

PhD students (2)

Andrew Burchill, Animal Behavior PhD Student, 2015–2022 [now Data Scientist for City of Scottsdale] Taeyeong Choi, Computer Science PhD Student, 2016–2020 [now **Asst Prof**, Kennesaw State U.]

Master's students (3)

Swastik Nandan, Robotics and Automation Systems MS Student, 2021–2022 Sehyeok Kang, Computer Engineering MS Student, 2019–2020 Christian Seto, Industrial Engineering MS Student, 2017–2018

Undergraduate honors students (8)

Emily Ladewig, Sustainability BS Student [honors thesis], 2022–2023
Liyah Coleman, Biology BS Student [honors thesis], 2021–2023
Liliaokeawawa Cothren, Applied Mathematics BS Student [honors thesis], 2019–2021
Samantha Castro, Biology BS Student [honors thesis], 2019–2020
Jeanbat Busisi, Industrial Engineering BS Student [honors thesis], 2018–2019
Danielle Adams, Industrial Engineering BS Student [honors thesis], 2018–2019
Erin Glavin, Industrial Engineering BS Student [honors thesis], 2017–2018
Mikaela Hall, Industrial Engineering BS Student [honors thesis], 2016–2017

CURRENT STUDENT MENTEES [ADVISING CHAIR or CO-CHAIR]

PhD students (7)

Anoushka Dasgupta, Animal Behavior PhD Student, 2023–present Elena Oikonomou, Computer Engineering PhD Student, 2023–present Albert Chu, Computer Science PhD Student, 2023–present Joshua Elkins, Computer Science PhD Student, 2022–present Jinyung Hong, Computer Science PhD Student, 2019–present Colin Lynch, Animal Behavior PhD Student, 2019–present Xin Su, Industrial Engineering PhD Student, 2015–present

Master's students (2)

Keun Hee Park, Computer Science MS Student, 2023–present Adam Hardy, Robotics and Automation Systems MS Student, 2023–present

<u>Undergraduate students (3)</u>

Krish Bhalla, Biological Sciences (Biomed. Sciences) BS Student [undergraduate researcher], 2023—present Amrit Kaur, Biomedical Engineering BS Student [undergraduate researcher], 2023—present Alexander Edmiston, Industrial Engineering BS Student [honors thesis], 2023—present