

John Harwell

Curriculum Vitae

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Education

- 2016–2022 **Ph.D. in Computer Science**, *University of Minnesota Twin Cities*.
2016–2018 **M.S. in Computer Science**, *University of Minnesota Twin Cities*.
2009–2013 **B.S. in Computer Science and Engineering**, *University of Wisconsin-Madison*.

Ph.D. Thesis

- Title *Analysis of Collective Behavior in Robot Swarms*
Advisor Dr. Maria Gini
Description This thesis developed new theoretical tools for measuring, modeling, controlling, and (critically) predicting the behavior of bio-inspired multi-agent systems from small (≤ 5 agents) to large ($\geq 10,000$ agents) scales. Applications to foraging and construction tasks in dynamic, dangerous, and unknown environments.

Research Interests

Bio-inspired algorithms and design for dangerous and dynamic environments with unreliable communication and unknown workloads. Multi-agent modeling, task allocation, stochastic and differential equation modeling, graph theory, queueing theory approaches.

Publications

- [1] **J. Harwell**, L. Lowmanstone, M. Gini. "A Lattice Model of 3D Environments For Provable Manipulation". In: *Proceedings of the 22th International Conference on Autonomous Agents and MultiAgent Systems*. AAMAS '23. International Foundation for Autonomous Agents and Multiagent Systems, **2023**, XX–YY.
- [2] **J. Harwell**, L. Lowmanstone, M. Gini. "SIERRA: A Modular Framework for Accelerating Research and Improving Reproducibility". In: *2023 International Conference on Robotics and Automation (ICRA)*. **2023**, XX–YY.
- [3] **J. Harwell**, L. Lowmanstone, M. Gini. "SIERRA: A Modular Framework for Research Automation". In: *Proc. Int'l Conf. on Autonomous Agents and Multiagent Systems (AAMAS)*. Virtual Event, New Zealand, **2022**, pp. 1905–1907.
- [4] **J. Harwell**, A. Sylvester, M. Gini. "Characterizing The Limits of Linear Modeling of Non-Linear Swarm Behaviors". In: *Autonomous Robots* (**2022**). Under review. URL: <http://arxiv.org/abs/2110.12307>.
- [5] M. Jeong, **J. Harwell**, M. Gini. "Analysis of Exploration in Swarm Robotic Systems". In: *Intelligent Autonomous Systems 16*. Ed. by Marcelo H. Ang Jr, Hajime Asama, Wei Lin, and Shaohui Foong. Cham: Springer International Publishing, **2022**, pp. 445–457.
- [6] **J. Harwell**, M. Gini. "Improved Swarm Engineering: Aligning Intuition and Analysis". In: *Robotics and Autonomous Systems* (**2021**). URL: <http://arxiv.org/abs/2012.04144>.
- [7] **J. Harwell**. "A Theoretical Framework for Self-Organized Task Allocation in Large Swarms (Doctoral Consortium)". In: *Proc. Int'l Conf. on Autonomous Agents and Multi-Agent Systems (AAMAS)*. Richland, SC, **May 2020**, pp. 2191–2192.

- [8] **J. Harwell**, L. Lowmanstone, M. Gini. “Demystifying Emergent Intelligence And Its Effect On Performance In Large Robot Swarms”. In: *Proc. Int’l Conf. on Autonomous Agents and Multi-Agent Systems (AAMAS)*. **May 2020**, pp. 474–482.
- [9] A. Chen, **J. Harwell**, M. Gini. *Maximizing Energy Battery Efficiency in Swarm Robotics*. **2019**. URL: <http://arxiv.org/abs/1906.01957>.
- [10] **J. Harwell**. “A Unified Mathematical Approach for Foraging and Construction Systems in a 1,000,000 Robot Swarm”. In: *Proceedings of the Twenty-Eighth International Joint Conference on Artificial Intelligence, IJCAI-19*. International Joint Conferences on Artificial Intelligence Organization, **July 2019**, pp. 6438–6439.
- [11] **J. Harwell**, M. Gini. “Swarm Engineering Through Quantitative Measurement of Swarm Robotic Principles in a 10,000 Robot Swarm”. In: *Proc. 28th Int’l Joint Conf. on Artificial Intelligence (IJCAI-19)*. **July 2019**, pp. 336–342.
- [12] N. White, **J. Harwell**, M. Gini. *Socially Inspired Communication in Swarm Robotics*. **2019**. URL: <http://arxiv.org/abs/1906.01108>.
- [13] **J. Harwell**, M. Gini. “Broadening applicability of swarm-robotic foraging through constraint relaxation”. In: *IEEE Int’l Conf. on Simulation, Modeling, and Programming for Autonomous Robots (SIMPAN)* (**May 2018**), pp. 116–122.
- [14] H. Baaolu, J. Blount, J. Blount, B. Nelson, S. Succi, P. M. Westhart, J. R. Harwell. “Computational performance of SequenceL coding of the lattice Boltzmann method for multi-particle flow simulations”. In: *Computer Physics Communications* 213 (**2017**), pp. 92–99.

Experience

- 2022–present **Researcher**, SMART INFORMATION FLOW TECHNOLOGIES , Minneapolis, MN.
 - Independently identified project work and successfully executed tasks with minimal oversight.
 - Contributed to business development through market research and proposal writing.
 - Developed models of flocking behaviors to extract control policies and parameters automatically from trajectory data to estimate physical properties and limits of vehicles.
 - Reduced debugging time by enhancing in-house tooling for efficient visualization of multi-variate spatio-temporal data of large-scale multi-agent systems.
- 2016–2022 **Researcher**, UNIVERSITY OF MINNESOTA, Minneapolis, MN.
 - Derived cuboid structure model using graph theory to develop simple algorithms to provably manipulate graphs (structures) from one state to another [1].
 - Demonstrated robust predictions of steady-state collective foraging behaviors up to practical engineering limits using ODEs [4].
 - Showed that the origin of collective intelligence in task allocating swarms lies in self-organized learning task relationships, rather than costs [8].
 - Reduced development cycles and increased utility of automated design methods through of better measurements for design principles of multi-agent systems.
- 2016–2022 **Developer**, RESEARCH LIBRARIES FOR SWARM ROBOTICS,  Github.
 - Innovated automated research pipeline: generating inputs, running experiments, processing results, and generating camera-ready deliverables [3, 2].
 - Supported R&D through application of design patterns, modern language features to maximize reusability.
 - Supported R&D through iterative profiling and refinement of computationally intensive simulations for deployment on High Performance Computing (HPC) clusters.
- 2016–2022 **Mentor and Advisor**, UNIVERSITY OF MINNESOTA, Minneapolis, MN.
 - Designed engaging opportunities including contributing to published papers and large C++ software projects for high school and undergraduate students.
 - Mentored undergraduate students interested in AI, robotics, and academic research to apply for grants, publish original research, and present at workshops [9, 12, 5].
- 2013–2016 **Research Engineer**, SOUTHWEST RESEARCH INSTITUTE, San Antonio, TX.
 - Reduced computing costs through computational optimization of large-scale simulations [14].
 - Lead flight software developer on NASA subcontract for unmanned satellite constellation.
 - Enhanced utility of POSIX-flavored filesystems for embedded spacecraft applications by developing new file system with smaller, configurable memory footprint and increased robustness.

Fellowships and Awards

- 2022 DAAD AInet Fellow - AI and Robotics (\$N/A)
2020–2021 UMII MnDRIVE Graduate Fellowship (\$51,177)
2019–2020 GAANN Fellowship (\$20,560)

Presentations

- 2022 A LATTICE MODEL OF MANIPULABLE ENVIRONMENTS FOR PROVABLE MANIPULATION, International Conference on Autonomous Agents and MultiAgent Systems (AAMAS) ARMS Workshop
- 2021 A ROBUST MODEL FOR PREDICTING COLLECTIVE BEHAVIOR IN LARGE ROBOT SWARMS, International Conference on Robotics and Automation (ICRA) Real World Swarms Workshop
- 2020 DEMYSTIFYING EMERGENT INTELLIGENCE AND ITS EFFECT ON PERFORMANCE IN LARGE ROBOT SWARMS, International Conference on Autonomous Agents and MultiAgent Systems (AAMAS)
- 2020 A THEORETICAL FRAMEWORK FOR SELF-ORGANIZED TASK ALLOCATION IN LARGE SWARMS, International Conference on Autonomous Agents and MultiAgent Systems (AAMAS) Doctoral Consortium
- 2020 ROBUSTNESS ANALYSIS IN LARGE ROBOT SWARMS, International Conference on Autonomous Agents and MultiAgent Systems (AAMAS) ARMS Workshop
- 2019 SWARM ENGINEERING THROUGH QUANTITATIVE MEASUREMENT IN 10,000 ROBOT SWARMS, International Joint Conference on Artificial Intelligence (IJCAI)
- 2019 FROM FORAGING TO CONSTRUCTION IN A 1,000,000 ROBOT SWARM, International Joint Conference on Artificial Intelligence (IJCAI) Doctoral Consortium
- 2018 BROADEN APPLICABILITY OF SWARM-ROBOTIC FORAGING THROUGH CONSTRAINT RELAXATION, International Conference on Simulation, Modeling, and Programming for Autonomous Robots (SIMPAN)
- 2018 GENERALIZING TASK PARTITIONING APPROACHES TO ROBOT SWARM FORAGING, International Conference on Robotics and Automation (ICRA) Real World Swarms Workshop
- 2015 A SIMPLE FLASH FILE SYSTEM FOR EMBEDDED SPACE APPLICATIONS, Flight Software Workshop

Teaching Experience

- Spring 2021 **Instructor**, INTRODUCTION OF COMPUTING AND PROGRAMMING CONCEPTS, University of Minnesota, Department of Computer Science.
Introductory undergraduate python course via Zoom (30 students).
 - Covered OOP paradigm, algorithmic fundamentals and control flow, and basics of version control and IDEs.
 - Developed new course material, assignments, and exam questions.
- 2016–2018 **Teaching Assistant**, SOFTWARE DESIGN AND DEVELOPMENT, University of Minnesota, Department of Computer Science.
Guided students (class size 100+) in developing a large-scale C++ software project.
 - Tutored students in application of software design principles.
 - Introduced students to common industry toolchains (git, cmake, gcc, gdb).
 - Comprehensively answered student questions in weekly office hours, and actively engaged students with weekly hands-on labs covering course material.

Technical Skills

- Theory Bio-inspired modeling, stochastic processes, differential equation modeling, graph theory, queueing theory

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| Algorithms | Parallel, greedy, biomimetic, graphical, distributed task allocation |
| Data Structures | Graphs, trees, R-trees, Poisson queues, heaps, maps, C++ STL |
| Languages | Proficient: C (kernel/embedded systems programming) C++ (C++17, templates, metaprogramming) Python (data visualization/processing, REST) Familiar: Fortran, SPARC, bash, MATLAB |
| Interfaces | Proficient: Boost, OpenMP, pandas, matplotlib Familiar: MPI, FPGA specs, UART, I2C |
| Software Development | Writing: Design patterns, OOP, polymorphism, concurrent programming Devops: GitHub Actions, GitLab CI Tools: Intel/GNU compilers, LLVM toolchain, cmake, gdb, valgrind, VTune, git |
| Platforms | Linux: Ubuntu, Raspberry Pi Real-time OS: RTEMS Robotics: ARGoS, ROS, Turtlebot3 High Performance Computing (HPC): SLURM, PBS |

Service and Outreach

- 2022-Present **Committee Involvement**, JOURNALS AND CONFERENCES.
- 2022 Autonomous Robots and Multi-Robot Systems (ARMS) Program Committee
 - 2023 Autonomous Agents and Multi-Agent Systems (AAMAS) Program Committee
 - 2023 Associate for the Advancement of Artificial Intelligence (AAAI) Program Committee
- 2018-Present **Ad Hoc Reviewer**, JOURNALS AND CONFERENCES.
- Frontiers in Robotics and AI
 - Transactions on Robotics (TRO)
 - Autonomous Agents and Multi-Agent Systems (AAMAS, AGNT)
 - International Conference on Artificial Intelligence (IJCAI)
 - International Conference on Robotics and Automation (ICRA)
 - Swarm Intelligence
 - International Conference on Intelligent Robots and Systems (IROS)
- 2018–2019 **Instructor**, MNDRIVE SUMMER TECHNOLOGY CAMP, University of Minnesota.
Led outreach activities at broadening the interests of elementary and middle school students in historically underrepresented demographics in STEM.
- 2018–2020 **Instructor**, MNDRIVE YOUTH TECHNOLOGY OUTREACH, Minneapolis, MN.
Designed accessible science curriculum and led bi-weekly programming, Arduino, or science related activities. Orchestrated student groups to foster collaboration on technically challenging tasks.

References

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¹Teaching reference.