John Harwell

Curriculum Vitae

(651) 261–2862
john.r.harwell@gmail.com
https://jharwell.github.io
Google Scholar
Github

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: *Proc. Int'l Conf. on Autonomous Agents and Multiagent Systems (AAMAS)*. **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*. arXiv:2110.12307v2 [cs.RO]. **2022**.

[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: *IEEE Transactions on Robotics* **(2021)**.

[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, **May 2018**, pp. 116–122.

[14] H. Başağaoğlu, 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 multivariate 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 differential equation models [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 better measurements for design principles of multi-agent systems.

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 in collaboration with the University of Michigan.
- Enhanced utility of POSIX-flavored filesystems for embedded spacecraft applications by developing new file system with smaller, configurable memory footprint and increased robustness.

Projects

2016-present **Maintainer**, Core Swarm Library, Github
- Middleware-esque C++ library providing a common, zero-cost API to different platforms, transparently for both real and simulated robot types.
- C++17 compliant with strong focus on reusability. Integration with Boost.
- Computationally optimized: Demonstrated efficient execution with systems of over 10,000 robots on HPC clusters and on real systems of Raspberry PI-powered robots.

2017-present **Maintainer**, SIERRA: Scientific Method Automation, Github
- Given a user query of an independent variable over a range, generate experimental inputs, run experiments, process results, and generate visualizations [2].
- Plugin-based python framework supports any agent type, platform (e.g., simulator, ROS, real robot), or execution environment (e.g., HPC cluster, real robot).

2016–2022 **Author**, FORDYCA: Foraging Robots use Dynamic Caches, Github
- Consistent use of design principles: SOLID, DRY/WET, interface segregation, etc.
- Scalable events-based architecture to drive agent controllers.
- Novel generic event dispatch approach via compile-time reflection.

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 (SIMPAR)

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 object oriented programming, algorithmic fundamentals and control flow, and basics of version control and development environments.
- 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-inpsired modeling, stochastic processes, differential equation modeling, graph theory, queueing theory

Algorithms Parallel, greedy, biomimetic, graphical, distributed task allocation

Data Structures Graphs, trees, R-trees, Poisson queues, heaps, maps, C++ STL

Platforms Linux: Ubuntu, Raspberry PI
Real-time OS: RTEMS
Robotics: ARGoS, ROS, Turtlebot3
High Performance Computing (HPC): SLURM, PBS

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

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 aimed 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

Dr. Maria Gini
Department of Computer Science
University of Minnesota
gini@umn.edu
(612) 625–5582

Dr. Nikolaos Papanikolopoulos
Department of Computer Science
University of Minnesota
papan001@umn.edu
(612) 625–0163

Dr. Shana Watters[1]
Department of Computer Science
University of Minnesota
watt0087@umn.edu
(612) 626–9381

Dr. Junaed Sattar
Department of Computer Science
University of Minnesota
junaed@umn.edu
(612) 626–7235

Dr. Emilie Snell-Rood
Department of Evolution, Ecology, and Behavior
University of Minnesota
emilies@umn.edu
(612) 624–7238

[1] Teaching reference.