John Harwell

Curriculum Vitae

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Education

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

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.

Experience

2022–present	**Researcher**, SMART INFORMATION FLOW TECHNOLOGIES , Minneapolis, MN

- ⭘ Developed simulation models of multi-agent system flocking behaviors to extract control policies and parameters automatically from trajectory data of fixed-wing aircraft and quad-copters. Applications to estimation of physical properties and limits of vehicles.
- ⭘ Automated usage of JAMIS-ERP to streamline proposal, project tracking activities.
- ⭘ Enhanced in-house tooling for efficient visualization of multi-variate spatio-temporal data of large-scale multi-agent systems on automated (re)-planning tasks in simulated worlds.

2016–2022 **Academic Researcher**, University of Minnesota, Minneapolis, MN
Investigated self-organizing structures in multi-robot systems, how collective behaviors in multi-robot systems can be predicted from first principles, and how to better measure system behaviors. Developed partial solution to the Parallel Bricklayer Problem.
- ○ Cuboid structure modeling using graph theory to develop simple algorithms to provably manipulate graphs (structures) from one state to another.
  - – Funded through a Graduate Research Fellowship.
- ○ Modeled Poisson and non-Poisson distribution collective behaviors using Ordinary Differential Equations (ODEs) and first-principle derivations in a foraging task [3].
  - – Funded through a UMII Fellowship and a Graduate Research Fellowship.
- ○ Collaborative effort to investigate the origin of collective intelligence using task allocation, graph theory, and matroids [10, 6].
  - – Funded through a UMII Assistantship and GAANN Fellowship.
- ○ Developed methodology for measuring major design principles of multi-robot systems: scalability, self-organization, flexibility, and robustness; application to real-world foraging scenarios [8, 5].
  - – Funded through GAANN, UMII Fellowships and a Graduate Research Fellowship.

2016-2022 **Developer**, Research Libraries for Swarm Robotics, ⬡ Github
- ○ Innovated automated research pipeline: generating inputs, running experiments, processing results, and generating camera-ready deliverables [2, 1].
- ○ 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
Mentored high school and undergraduate students interested in AI and robotics.
- ○ Designed engaging opportunities including contributing to published papers and large C++ software projects.
- ○ Guided multiple undergraduates interested in graduate school and academic research.
  - – Three successfully applied for undergraduate research grants.
  - – Three successfully published and presented original research at workshops and conferences [7, 9, 4].

Summer 2017 **Software Development Intern**, Cray, Inc., Minneapolis, MN
Built reusable Linux kernel modules for HPC environments to reduce development cycle time of Cray DataWarp software.

2013–2016 **Research Engineer**, Southwest Research Institute, San Antonio, TX
Reduced computing costs through computational optimization of computationally intensive simulations [11]. Engineered high quality software for embedded systems, specializing in avionics and spacecraft applications.
- ○ Application of genetic algorithms to maximize performance of fluid flow simulations with temporally varying computational characteristics on heterogeneous cluster hardware.
- ○ Developed flight software for 8 satellite constellation for hurricane monitoring as main developer of bootstrap, system device drivers, and onboard scientific data processing in collaboration with NASA and 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 compared to current solutions.

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 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.

Skills

Theory	Stochastic processes, ODE modeling, graph theory, queueing theory, linear optimization, code performance analysis
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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[1]Teaching reference.