Joshua J. Daymude

Arizona State University, Tempe, Arizona, USA
jdaymude@asu.edu
jdaymude.github.io
PhD Candidate, Computer Science

Education

Aug. 2016 – * **Computer Science (Ph.D.)**, *Arizona State University*, Tempe, Arizona, USA, 4.00 GPA.
Expected Graduation Date: March 2021

Fall 2017 **Visiting Scholar**, *Georgia Institute of Technology*, Atlanta, Georgia, USA.

Aug. 2012 – Aug. 2016 **Computer Science (B.S.) & Mathematics (B.S.)**, *Barrett, the Honors College at Arizona State University*, Tempe, Arizona, USA, Summa Cum Laude, 4.00 GPA.

Theses

March 2021 **PhD Dissertation**, *Collaborating in Motion: Distributed Algorithms for Programmable Matter and Dynamic Graphs*, Arizona State University.

Apr. 2016 **Undergraduate Honors Thesis**, *Compression in Self-Organizing Particle Systems*, Barrett, the Honors College at Arizona State University.

Research

Aug. 2016 – * **A Distributed, Stochastic Framework for Active Matter**, Arizona State University, USA.
With my advisor Prof. Andréa W. Richa and in collaboration with Profs. Dana Randall and Daniel I. Goldman, we develop a theoretical framework for task-oriented *active matter* that combines distributed computing, stochastic processes, statistical physics, and robophysics. By harnessing phase changes from statistical physics in our formal modeling and algorithm design, we obtain robust and provable self-organizing behaviors. We then incorporate this theory into swarm robotics platforms, establishing tight analogies between the algorithms' rules and our robots' designs. This allows us to critically examine our theoretical algorithms' robustness to the errors and uncertainties of physical environments. Further, we can treat robot swarms as macro-scale active matter systems, studying the inter-robot dynamics as an analogy to particle interactions.

Apr. 2014 – * **Self-Organizing Particle Systems**, Arizona State University, USA.
With my advisor Prof. Andréa W. Richa and in collaboration with Prof. Christian Scheideler, we study programmable matter and self-organizing systems from the perspective of distributed computing. Under our *amoebot model*, we develop fully local, distributed algorithms which enable individual computational particles to self-organize and solve problems of movement and coordination without any centralized control. Each algorithm is rigorously analyzed for correctness, runtime, and practical efficiency in an effort to capture many assumptions and physical properties of implemented systems in our general, theoretical model. For more, see `sops.engineering.asu.edu`.

Jun. 2015 – Aug. 2015 **Self-Organizing Particle Systems**, Universität Paderborn, Germany.
I continued my undergraduate thesis research in self-organizing particle systems with Profs. Richa and Scheideler through RISE, a research assistant exchange program sponsored by the German Academic Exchange Service (DAAD). We accomplished (i) a local control protocol and visual simulation for *leader election*, (ii) algorithms for *hole elimination*, and (iii) proofs of correctness and a competitive analysis among the proposed algorithms.

Aug. 2012 – May 2013 **STARS Leadership Corps**, Arizona State University, USA.
I worked under Dr. Winslow Burleson to make High Performance Computing more accessible to K–12 students by curating and developing content for a self-guided learning website. I was personally responsible for (i) writing tutorials which covered the basics of the OpenMPI protocol and (ii) developing interactive activities for elementary school students that demonstrated the power of concurrency and the cost of parallel overhead.

Publications

Please note that in many of the citations below (especially in algorithms and theoretical computer science), authors appear in alphabetical order. BibTeX entries, DOIs, and PDFs for all publications can be found on my website at `https://jdaymude.github.io`.

Book Chapters

Jan. 2019 **Computing by Programmable Particles**, *Joshua J. Daymude, Kristian Hinnenthal, Andréa W. Richa, and Christian Scheideler*, Distributed Computing by Mobile Entities, pp. 615–681, (Invited submission).

Refereed Journal Papers

In Preparation **Preventing Extreme Polarization of Political Attitudes**, *Robert Axelrod, Joshua J. Daymude, and Stephanie Forrest*, Manuscript in preparation.

In Preparation **A Local Stochastic Algorithm for Separation in Heterogeneous Self-Organizing Particle Systems**, *Sarah Cannon, Joshua J. Daymude, Cem Gokmen, Dana Randall, and Andréa W. Richa*, Manuscript in preparation.

In Preparation **A Markov Chain Algorithm for Compression in Self-Organizing Particle Systems**, *Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa W. Richa*, Manuscript in preparation.

In Preparation **Simulation of Programmable Matter Systems Using Active Tile-Based Self-Assembly**, *John Calvin Alumbaugh, Joshua J. Daymude, Erik D. Demaine, Matthew J. Patitz, and Andréa W. Richa*, Manuscript in preparation, (Invited submission to Special Issue of Natural Computing for DNA25).

Submitted **Programming Active Granular Matter with Mechanically Induced Phase Changes**, *Bahnisikha Dutta, Shengkai Li, Sarah Cannon, Joshua J. Daymude, Ram Avinery, Enes Aydin, Andréa W. Richa, Daniel I. Goldman, and Dana Randall*, Submitted and under review.

Dec. 2018 **A Stochastic Approach to Shortcut Bridging in Programmable Matter**, *Marta Andrés Arroyo, Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa W. Richa*, Natural Computing, 17(4) pp. 723–741, (Invited submission to Special Issue for DNA23).

Dec. 2018 **Phototactic Supersmarticles**, *William Savoie, Sarah Cannon, Joshua J. Daymude, Ross Warkentin, Shengkai Li, Dana Randall, Andréa W. Richa, and Daniel I. Goldman*, Artificial Life and Robotics, 23(4) pp. 459–468, (Invited submission to Special Issue for SWARM 2017).

Mar. 2018 **On the Runtime of Universal Coating for Programmable Matter**, *Joshua J. Daymude, Zahra Derakhshandeh, Robert Gmyr, Alexandra Porter, Andréa W. Richa, Christian Scheideler, and Thim Strothmann*, Natural Computing, 17(1) pp. 81–96, (Invited submission to Special Issue for DNA22).

Conference Proceedings Refereed Papers

In Preparation **Concurrency Control in the Amoebot Model**, *Joshua J. Daymude, Andréa W. Richa, and Christian Scheideler*, Manuscript in preparation.

Jan. 2021 **Bio-Inspired Energy Distribution for Programmable Matter**, *Joshua J. Daymude, Andréa W. Richa, and Jamison W. Weber*, International Conference on Distributed Computing and Networking 2021 (ICDCN 2021), pp. 86–95, Nara, Japan (Virtual Event).

Jan. 2020 **Convex Hull Formation for Programmable Matter**, *Joshua J. Daymude, Robert Gmyr, Kristian Hinnenthal, Irina Kostitsyna, Christian Scheideler, and Andréa W. Richa*, Proceedings of the 21st International Conference on Distributed Computing and Networking (ICDCN 2020), pp. 2:1–2:10, Kolkata, India.

Sep. 2019 **A Local Stochastic Algorithm for Separation in Heterogeneous Self-Organizing Particle Systems**, *Sarah Cannon, Joshua J. Daymude, Cem Gokmen, Dana Randall, and Andréa W. Richa*, Approximation, Randomization, and Combinatorial Optimization (APPROX/RANDOM 2019), pp. 54:1–54:22, Boston, MA, USA.

Aug. 2019 **Simulation of Programmable Matter Systems Using Active Tile-Based Self-Assembly**, *John Calvin Alumbaugh, Joshua J. Daymude, Erik D. Demaine, Matthew J. Patitz, and Andréa W. Richa*, DNA Computing and Molecular Programming – 25th International Conference (DNA25), pp. 140–158, Seattle, WA, USA.

Jul. 2018 **Brief Announcement: A Local Stochastic Algorithm for Separation in Heterogeneous Self-Organizing Particle Systems**, *Sarah Cannon, Joshua J. Daymude, Cem Gokmen, Dana Randall, and Andréa W. Richa*, Proceedings of the 2018 ACM Symposium on Principles of Distributed Computing (PODC 2018), pp. 483–485, London, UK.

Sep. 2017 **A Stochastic Approach to Shortcut Bridging in Programmable Matter**, *Marta Andrés Arroyo, Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa W. Richa*, DNA Computing and Molecular Programming – 23rd International Conference (DNA23), pp. 122–138, Austin, TX, USA.

Sep. 2017 **Improved Leader Election for Self-Organizing Programmable Matter**, *Joshua J. Daymude, Robert Gmyr, Andréa W. Richa, Christian Scheideler, and Thim Strothmann*, Algorithms for Sensor Networks (ALGOSENSORS 2017), pp. 127–140, Vienna, Austria.

Jul. 2016 **A Markov Chain Algorithm for Compression in Self-Organizing Particle Systems**, *Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa Richa*, ACM Symposium on Principles of Distributed Computing (PODC 2016), pp. 279–288, Chicago, IL, USA.

Other Publications

Oct. 2017 **Phototactic Supersmarticles**, *Sarah Cannon, Joshua J. Daymude, William Savoie, Ross Warkentin, Shengkai Li, Daniel I. Goldman, Dana Randall, and Andréa W. Richa*, Appeared at the 2nd International Symposium on Swarm Behavior and Bio-Inspired Robotics (SWARM 2017), Kyoto, Japan.

Mar. 2016 **Leader Election and Shape Formation with Self-Organizing Programmable Matter**, *Joshua J. Daymude, Zahra Derakhshandeh, Robert Gmyr, Thim Strothmann, Rida A. Bazzi, Andréa W. Richa, and Christian Scheideler*, Available online at `https://arxiv.org/abs/1503.07991`.

Presentations

Invited Talks

Nov. 2018 **Self-Organizing Particle Systems: an Algorithmic Approach to Programmable Matter**, 2nd Workshop on Self-Organization in Swarm of Robots (WSSR 2018), Tokyo, Japan.

Conference Talks

Jan. 2021 **Bio-Inspired Energy Distribution for Programmable Matter**, International Conference on Distributed Computing and Networking (ICDCN) 2021, Nara, Japan (Virtual Event).

Sep. 2019 **A Local Stochastic Algorithm for Separation in Heterogeneous Self-Organizing Particle Systems**, International Conference on Randomization and Computation (RANDOM) 2019, Boston, MA, USA.

Apr. 2019 **Stochastic Algorithms for Programmable Matter**, Discrete Math Seminar, Arizona State University, Tempe, AZ, USA.

Oct. 2017 **A Stochastic Approach to Shortcut Bridging in Programmable Matter**, Algorithms, Combinatorics, and Optimization (ACO) Student Seminar, Georgia Institute of Technology, Atlanta, GA, USA.

Jul. 2017 **Local Stochastic Algorithms for Compression and Shortcut Bridging in Programmable Matter**, Biological Distributed Algorithms (BDA) 2017, Washington D.C., USA.

Jul. 2017 **Convex Hull Formation for Programmable Matter**, Biological Distributed Algorithms (BDA) 2017, Washington D.C., USA.

Jul. 2015 **Compaction and Expansion in Self-Organizing Particle Systems**, DAAD Research Internships in Science and Engineering (RISE) Scholars Meeting 2015, Heidelberg, Germany.

Poster Presentations

Sep. 2020 **Bio-Inspired Energy Distribution for Programmable Matter**, DNA Computing and Molecular Programming – 26th International Conference (DNA26), Virtual Presentation.

Apr. 2019 **Self-Organizing Particle Systems: an Abstraction of Programmable Matter**, Achievement Rewards for College Scientists (ARCS) Awards Dinner 2019, Phoenix, AZ, USA.

Apr. 2018 **Self-Organizing Particle Systems: an Abstraction of Programmable Matter**, Achievement Rewards for College Scientists (ARCS) Awards Dinner 2018, Phoenix, AZ, USA.

Jul. 2017 **Compression and Shortcut Bridging in Self-Organizing Particle Systems**, Google Ph.D Intern Research Conference (PIRC) 2017, Mountain View, California, USA.

Apr. 2016 **Compression in Self-Organizing Particle Systems**, Barrett Celebrating Honors Symposium (BCHS) 2016, Arizona State University, USA.

Aug. 2015 **Compaction and Expansion in Self-Organizing Particle Systems**, Biological Distributed Algorithms (BDA) 2015, Boston, Massachusetts, USA.

Jul. 2015 **Compaction and Expansion in Self-Organizing Particle Systems**, Structural Information and Communication Complexity (SIROCCO) 2015, Montserrat, Spain.

Apr. 2015 **Compaction in Self-Organizing Particle Systems**, Fulton Undergraduate Research Initiative (FURI) Symposium 2015, Arizona State University, USA.

Apr. 2015 **Self-Organizing Particle Systems**, Barrett Celebrating Honors Symposium (BCHS) 2015, Arizona State University, USA.

Teaching & Advising

Courses Taught

Fall 2019 **CSE 598: Markov Chain and Monte Carlo Methods**, *Developer and Instructor*, Arizona State University, Course Evaluation: 4.54/5, Instructor Evaluation: 4.81/5.

Courses Assisted

Fall 2020 **CSE 550: Combinatorial Algorithms and Intractability**, *Teaching Assistant*, Arizona State University, Assisted Prof. Andréa Richa in transitioning the course to a hybrid (ASU Sync) format, holding office hours, grading, and preparing lecture slides, homework assignments, and exams.

Fall 2019 **CSE 552: Randomized and Approximation Algorithms**, *Teaching Assistant*, Arizona State University, Assisted Prof. Andréa Richa by holding office hours and preparing and grading homework assignments and exams.

Fall 2014 **MAT 208: Discrete Mathematics for Secondary Teachers**, *Undergraduate Instructor's Assistant*, Arizona State University, Assisted Prof. Hal Kierstead by holding office hours and preparing homework solutions and student study materials.

Students Supervised

2020 – * **Noble Harasha**, *High School Research Assistant*, Peggy Payne Academy at McClintock High School.

2019 – 2020 **Ziad Abdelkarim**, *Undergraduate Research Assistant*, Arizona State University.

2018 – 2020 **Ryan Yiu**, *Graduate Research Assistant*, Arizona State University.

2018 – 2020 **Joseph Briones**, *Undergraduate Research Assistant*, Arizona State University.

2018 – 2019 **Christopher Boor**, *Undergraduate Research Assistant*, Arizona State University.

2017 – 2019 **Kevin Lough**, *Undergraduate Research Assistant*, Arizona State University.

2017 – 2018 **Cem Gökmen**, *Undergraduate Research Assistant*, Georgia Institute of Technology.

Summer 2017 **Marta Andrés Arroyo**, *Undergraduate Research Assistant*, Georgia Institute of Technology.

2015 – 2016 **Michaela Murray**, *High School Research Assistant*, BASIS.

Honors and Awards

Feb. 2020 **Johnston Endowment Scholar (2020–2021)**, *Achievement Rewards for College Scientists (ARCS) Foundation, Phoenix Chapter*.

Feb. 2019 **Johnston Endowment Scholar (2019–2020)**, *Achievement Rewards for College Scientists (ARCS) Foundation, Phoenix Chapter*.

Feb. 2018 **Johnston Endowment Scholar (2018–2019)**, *Achievement Rewards for College Scientists (ARCS) Foundation, Phoenix Chapter*.

Jan. 2018 **Graduate College Fellowship (Spring 2018)**, *Arizona State University Graduate College*.

May 2016 **Moeur Award**, *Arizona State University Alumni Association*.

Apr. 2016 **Dean's Fellowship Award**, *School for Computing, Informatics, Decision Systems Engineering*, Arizona State University.

Mar. 2016 **Honorable Mention, Graduate Research Fellowship Program**, *National Science Foundation*.

Mar. 2016 **Research Experience for Undergraduates (REU)**, *National Science Foundation*.

Dec. 2015 **Honorable Mention, Outstanding Undergraduate Male Researcher Award for Ph.D Granting Institutions**, *Computing Research Association*.

Jun. 2015 **Research Internships in Science and Engineering (RISE) Scholarship**, *German Academic Exchange Service (DAAD)*, Universität Paderborn, Germany.

Jan. 2015 **FURI Grant**, *Fulton Undergraduate Research Initiative*, Arizona State University.

Oct. 2014 **Research Experience for Undergraduates (REU)**, *National Science Foundation*.

Jan. 2012 **Regional Outstanding: High School Mathematical Contest in Modeling**, *Consortium for Mathematics and its Applications*.

Jan. 2012 **National Merit Scholar**, *National Merit Scholarship Corporation*.

Employment

May 2019 – Aug. 2019 **Team Lead Research Intern**, Systems Imagination, Tempe, Arizona, USA.
I led a team of three in researching and implementing state of the art computer vision techniques for semantic and conceptual understanding of visual scenes. We explored many machine learning approaches (both with and without neural networks) to compare their viability for our applications, and ultimately created a hybrid of several sophisticated approaches. My team had high school and undergraduate students, so mentoring and teaching were also important responsibilities of my role.

May 2017 – Aug. 2017 **Software Engineering Intern**, Google, Inc., Mountain View, California, USA.
I worked for the Location team within Geo to develop an image-based machine learning approach for determining if a user is at a place or in transit, enabling better recognition of place entries and departures. I obtained TensorFlow training examples for this task from a data processing pipeline I developed to transform location traces into graphical representations on the world map. Using these examples, I trained a convolutional Inception-v4 neural network which achieved a classification accuracy of 88%, verifying the plausibility of this approach and informing directions for future work.

May 2014 – Aug. 2016 **Software Engineering Intern**, Jet Propulsion Laboratory, Pasadena, California, USA.
I worked as a software engineer in JPL's Ground Systems Engineering division, focusing on a subsystem of the Deep Space Network (DSN) known as Data Capture and Delivery (DCD). The DCD is responsible for the reliable capture of data received from space-to-ground downlink or generated by tracking activities, and the delivery of such data to mission scientists. My completed projects, spread across three internships with the DCD team, are detailed below.

- **Summer 2016:** Developed an artificial intelligence neural network for bandwidth prediction and an associated training framework from scratch, executed successful neural net training using raw network traffic data from the DCD, and performed detailed analysis of the suitability of various neural net architectures and learning algorithms.
- **Winter 2014:** Integrated Coverity static analysis into the makefiles of the DCD's source code.
- **Summer 2014:** Rewrote a large C library responsible for logging accountability data streaming from deep space spacecraft to improve subsystem stability and robustness. Developed a Solaris 10 SMF script for ensuring tracking system reliability even in the case of hardware failure. Developed a Perl script that synchronizes code changes between Git and Harvest repositories. Led experimental projects in iOS, Android, and Google Glass application development to create useful apps for the full-time engineers. Completed an iOS app that synchronizes meeting times across the three DSN headquarters in Australia, Spain, and the United States.

May 2013 – Apr. 2014 **AppleCare iOS Tier 1 Advisor**, Apple, Inc., Tempe, Arizona, USA.
I provided frontline over-the-phone technical support to Apple customers seeking help with their iOS devices. During my employment, I received over fifty "Very Satisfied" customer satisfaction reports, with an average of 10–20% of my customers responding each month. This job helped me master both a large area of technical expertise in Apple products as well as vital people skills when navigating challenging and potentially emotional troubleshooting scenarios.