Joshua J. Daymude

Postdoctoral Researcher

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Research Interests

I research algorithmic theory for the efficient control, coordination, and characterization of collective emergent behavior. I leverage expertise in distributed computing, stochastic processes, swarm intelligence, and bio-inspired algorithms to characterize how local interactions induce large-scale phenomena in complex social, biological, and engineered systems.

Academic Appointments

Apr. 2021 – * **Postdoctoral Researcher**, *The Biodesign Center for Biocomputing, Security and Society, Arizona State University*, Tempe, AZ, USA.

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

Education

May 2021 **Computer Science (Ph.D.)**, *Arizona State University*, Tempe, AZ, USA.
- Dissertation. *Collaborating in Motion: Distributed and Stochastic Algorithms for Emergent Behavior in Programmable Matter*, March 2021.
- Advisor. Prof. Andréa W. Richa.

Aug. 2016 **Computer Science (B.S.) & Mathematics (B.S.)**, *Barrett, the Honors College at Arizona State University*, Tempe, AZ, USA.
- Summa Cum Laude, 4.00 GPA.
- Capstone Project. *Modding for Minecraft*, December 2015.
- Honors Thesis. *Compression in Self-Organizing Particle Systems*, April 2016.
- Advisor. Prof. Andréa W. Richa.

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

[1] Joshua J. Daymude, Kristian Hinnenthal, Andréa W. Richa, and Christian Scheideler. Computing by Programmable Particles. In *Distributed Computing by Mobile Entities: Current Research in Moving and Computing*, pages 615–681. Springer, Cham, January 2019.

Refereed Journal Publications

[2] John Calvin Alumbaugh, Joshua J. Daymude, Erik D. Demaine, Matthew J. Patitz, and Andréa W. Richa. Simulation of Programmable Matter Systems Using Active Tile-Based Self-Assembly. Submitted and under review, 2021.

[3] Robert Axelrod, Joshua J. Daymude, and Stephanie Forrest. Preventing Extreme Polarization of Political Attitudes. *Proceedings of the National Academy of Sciences*, 2021. In Press; preprint available online at `https://arxiv.org/abs/2103.06492`.

[4] Shengkai Li, Bahnisikha Dutta, Sarah Cannon, Joshua J. Daymude, Ram Avinery, Enes Aydin, Andréa W. Richa, Daniel I. Goldman, and Dana Randall. Programming Active Cohesive Granular Matter with Mechanically Induced Phase Changes. *Science Advances*, 7(17):eabe8494, April 2021.

[5] Marta Andrés Arroyo, Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa W. Richa. A Stochastic Approach to Shortcut Bridging in Programmable Matter. *Natural Computing*, 17(4):723–741, December 2018.

[6] William Savoie, Sarah Cannon, Joshua J. Daymude, Ross Warkentin, Shengkai Li, Andréa W. Richa, Dana Randall, and Daniel I. Goldman. Phototactic Supersmarticles. *Artificial Life and Robotics*, 23(4):459–468, December 2018.

[7] Joshua J. Daymude, Zahra Derakhshandeh, Robert Gmyr, Alexandra Porter, Andréa W. Richa, Christian Scheideler, and Thim Strothmann. On the Runtime of Universal Coating for Programmable Matter. *Natural Computing*, 17(1):81–96, March 2018.

Refereed Conference Publications

[8] Joshua J. Daymude, Andréa W. Richa, and Christian Scheideler. The Canonical Amoebot Model: Algorithms and Concurrency Control. In *35th International Symposium on Distributed Computing*, DISC 2021, Freiburg, Germany, October 2021. Accepted; preprint available online at `https://arxiv.org/abs/2105.02420`.

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

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

[11] Sarah Cannon, Joshua J. Daymude, Cem Gokmen, Dana Randall, and Andréa W. Richa. A Local Stochastic Algorithm for Separation in Heterogeneous Self-Organizing Particle Systems. In *Approximation, Randomization, and Combinatorial Optimization. Algorithms and Techniques*, APPROX/RANDOM 2019, pages 54:1–54:22, Boston, MA, USA, September 2019.

[12] John Calvin Alumbaugh, Joshua J. Daymude, Erik D. Demaine, Matthew J. Patitz, and Andréa W. Richa. Simulation of Programmable Matter Systems Using Active Tile-Based Self-Assembly. In *DNA Computing and Molecular Programming*, DNA 2019, pages 140–158, Seattle, WA, USA, August 2019.

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

[14] Marta Andrés Arroyo, Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa W. Richa. A Stochastic Approach to Shortcut Bridging in Programmable Matter. In *DNA Computing and Molecular Programming*, DNA 2017, pages 122–138, Austin, TX, USA, September 2017.

[15] Joshua J. Daymude, Robert Gmyr, Andréa W. Richa, Christian Scheideler, and Thim Strothmann. Improved Leader Election for Self-Organizing Programmable Matter. In *Algorithms for Sensor Systems*, ALGOSENSORS 2017, pages 127–140, Vienna, Austria, September 2017.

[16] Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa W. Richa. A Markov Chain Algorithm for Compression in Self-Organizing Particle Systems. In *Proceedings of the 2016 ACM Symposium on Principles of Distributed Computing*, PODC 2016, pages 279–288, Chicago, IL, USA, July 2016.

Other Publications

[17] Joshua J. Daymude. *Collaborating in Motion: Distributed and Stochastic Algorithms for Emergent Behavior in Programmable Matter*. PhD Thesis, Arizona State University, Tempe, AZ, March 2021. Available online at `http://login.ezproxy1.lib.asu.edu/login?url=https://www.proquest.com/dissertations-theses/collaborating-motion-distributed-stochastic/docview/2531565717/se-2?accountid=4485`.

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

[19] Joshua J. Daymude, Zahra Derakhshandeh, Robert Gmyr, Thim Strothmann, Rida Bazzi, Andréa W. Richa, and Christian Scheideler. Leader Election and Shape Formation with Self-Organizing Programmable Matter. This updated version of the DNA 2015 conference paper is available online at `https://arxiv.org/abs/1503.07991`, March 2016.

[20] Joshua J. Daymude. *Compression in Self-Organizing Particle Systems*. Undergraduate Honors Thesis, Barrett, the Honors College at Arizona State University, Tempe, AZ, April 2016. Available online at `https://repository.asu.edu/items/37219`.

Presentations

Conference Talks

[1] Joshua J. Daymude, Andréa W. Richa, and Jamison W. Weber. Bio-Inspired Energy Distribution for Programmable Matter. In *International Conference on Distributed Computing and Networking (ICDCN) 2021*, Nara, Japan (Virtual Event), January 2021.

[2] Sarah Cannon, Joshua J. Daymude, Cem Gokmen, Dana Randall, and Andréa W. Richa. A Local Stochastic Algorithm for Separation in Heterogeneous Self-Organizing Particle Systems. In *International Conference on Randomization and Computation (RANDOM)*, Boston, MA, USA, September 2019.

[3] Marta Andrés Arroyo, Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa W. Richa. Local Stochastic Algorithms for Compression and Shortcut Bridging in Programmable Matter. In *Biological Distributed Algorithms (BDA)*, Washington D.C., USA, July 2017.

[4] Joshua J. Daymude, Robert Gmyr, Andréa W. Richa, Christian Scheideler, and Thim Strothmann. Convex Hull Formation for Programmable Matter. In *Biological Distributed Algorithms (BDA)*, Washington D.C., USA, July 2017.

[5] Joshua J. Daymude, Robert Gmyr, Andréa W. Richa, Christian Scheideler, and Thim Strothmann. Compaction and Expansion in Self-Organizing Particle Systems. In *DAAD Research Internships in Science and Engineering (RISE) Scholars Meeting*, Heidelberg, Germany, July 2015.

Invited Talks

[6] Joshua J. Daymude. Algorithmic Foundations of Emergent Behavior in Analog Collectives. In *Seminar*, Santa Fe Institute, Santa Fe, NM, USA, July 2021.

[7] Marta Andrés Arroyo, Sarah Cannon, Joshua J. Daymude, Cem Gokmen, Dana Randall, and Andréa W. Richa. Stochastic Algorithms for Programable Matter. In *Discrete Math Seminar*, Arizona State University, Tempe, AZ, USA, April 2019.

[8] Joshua J. Daymude, Kristian Hinnenthal, Andréa W. Richa, and Christian Scheideler. Self-Organizing Particle Systems: an Algorithmic Approach to Programmable Matter. In *2nd Workshop on Self-Organization in Swarm of Robots (WSSR)*, Tokyo, Japan, November 2018.

[9] Marta Andrés Arroyo, Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa W. Richa. A Stochastic Approach to Shortcut Bridging in Programmable Matter. In *Algorithms, Combinatorics, and Opimization (ACO) Student Seminar*, Georgia Tech, Atlanta, GA, USA, October 2017.

Poster Presentations

[10] Joshua J. Daymude, Andréa W. Richa, and Jamison W. Weber. Bio-Inspired Energy Distribution for Programmable Matter. In *DNA Computing and Molecular Programming — 26th International Conference (DNA26)*, Virtual Presentation, September 2020.

[11] Joshua J. Daymude and Andréa W. Richa. Self-Organizing Particle Systems: an Abstraction of Programmable Matter. In *Achievement Rewards for College Scientists (ARCS) Awards Dinner*, Phoenix, AZ, USA, April 2019.

[12] Joshua J. Daymude and Andréa W. Richa. Self-Organizing Particle Systems: an Abstraction of Programmable Matter. In *Achievement Rewards for College Scientists (ARCS) Awards Dinner*, Phoenix, AZ, USA, April 2018.

[13] Marta Andrés Arroyo, Sarah Cannon, Joshua J. Daymude, Dana Randall, and Andréa W. Richa. Compression and Shortcut Bridging in Self-Organizing Particle Systems. In *Google Ph.D. Intern Research Conference (PIRC)*, Mountain View, CA, USA, July 2017.

[14] Joshua J. Daymude and Andréa W. Richa. Compression in Self-Organizing Particle Systems. In *Barrett Celebrating Honors Symposium (BCHS)*, Arizona State University, Tempe, AZ, USA, April 2016.

[15] Joshua J. Daymude, Miles Laff, Zahra Derakhshandeh, Robert Gmyr, Alexandra Porter, and Andréa W. Richa. Compaction and Expansion in Self-Organizing Particle Systems. In *Biological Distributed Algorithms (BDA)*, Boston, MA, USA, August 2015.

[16] Joshua J. Daymude, Miles Laff, Zahra Derakhshandeh, Robert Gmyr, and Andréa W. Richa. Compaction and Expansion in Self-Organizing Particle Systems. In *Structural Information and Communication Complexity (SIROCCO)*, Montserrat, Spain, July 2015.

[17] Joshua J. Daymude and Andréa W. Richa. Compaction in Self-Organizing Particle Systems. In *Fulton Undergraduate Research Initiative (FURI) Symposium*, Arizona State University, Tempe, AZ, USA, April 2015.

[18] Joshua J. Daymude, Miles Laff, and Andréa W. Richa. Self-Organizing Particle Systems. In *Barrett Celebrating Honors Symposium (BCHS)*, Arizona State University, Tempe, AZ, USA, April 2015.

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.

Undergraduate Research Assistants Supervised

2019 – 2020 **Ziad Abdelkarim**, *Arizona State University*.
2018 – 2020 **Ryan Yiu**, *Arizona State University*.
2018 – 2020 **Joseph Briones**, *Arizona State University*.
2018 – 2019 **Christopher Boor**, *Arizona State University*.
2017 – 2019 **Kevin Lough**, *Arizona State University*.
2017 – 2018 **Cem Gökmen**, *Georgia Institute of Technology*.
Summer 2017 **Marta Andrés Arroyo**, *Georgia Institute of Technology*.

High School Research Assistants Supervised

Summer 2021 **Nandini Ram**, *BASIS Chandler*.
Summer 2021 **Neha Vontela**, *BASIS Scottsdale*.
2020 – * **Noble Harasha**, *Peggy Payne Academy at McClintock High School*.
2015 – 2016 **Michaela Murray**, *BASIS Scottsdale*.

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*.

Industry Experience

May 2019 – Aug. 2019 **Team Lead Research Intern**, *Systems Imagination*, Tempe, AZ, 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, CA, 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, CA, 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.