Thomas A. Berrueta

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EXPERIENCE

California Institute of Technology
Postdoctoral Scholar, Computing + Mathematical Sciences
Autonomous Robotics and Control Laboratory — 2024-Present

Caltech Racer Indy Autonomous Challenge
Technical Team Lead and Project Manager — 2025-Present

IEEE Robotics and Automation Letters
Associate Editor — 2025-Present

EDUCATION

Northwestern University
Ph.D. in Mechanical Engineering, Presidential Fellow
Interactive and Emergent Autonomy Laboratory — 2017-2024

Harvey Mudd College
B.S. in Engineering, Graduated with Honors — 2013-2017

HONORS

- Northwestern University Presidential Fellowship (Highest Honor Attainable) — 2022-2024
- Microsoft Future Leader in Robotics and AI — 2024
- Schmidt Science Fellows Finalist — 2023
- Microsoft Ada Lovelace Fellowship Finalist — 2019
- Walter P. Murphy Fellowship — 2017-2018
- Harvey S. Mudd Merit Scholarship — 2013-2017
- Dean's List — 2013-2017

RESEARCH

Physical Active Learning
- My work explores how physics informs and complicates robot learning. I combine insights from optimal control, reinforcement learning, and statistical physics to develop more reliable algorithms for hardware systems with on-board autonomy in real-time.

PUBLICATIONS

Journal Papers (* indicates equal authorship)

- **T. A. Berrueta**, A. Pinosky, T. D. Murphey, "Maximum diffusion reinforcement learning." *Nature Machine Intelligence*, vol. 6, no. 5, pp. 504-514 (2024).
- A. T. Taylor, **T. A. Berrueta**, A. Pinosky, T. D. Murphey, "Safe coverage for heterogeneous systems with limited connectivity." *IEEE Robotics and Automation Letters*, vol. 9, no. 10, pp. 8866-8873 (2024).
- **T. A. Berrueta**, T. D. Murphey, R. L. Truby, "Materializing autonomy in soft robots across scales." *Advanced Intelligent Systems*, vol. 6, no. 2, 2300111 (2023).
- **T. A. Berrueta***, J. F. Yang*, A. M. Brooks, A. T. Liu, G. Zhang, D. G. Medrano, S. Yang, V. B. Koman, P. Chvykov, M. Z. Miskin, T. D. Murphey, M. S. Strano, "Emergent microrobotic oscillators via asymmetry-induced order." *Nature Communications*, vol. 13, 5734 (2022).
- J. F. Yang, A. T. Liu, **T. A. Berrueta**, G. Zhang, A. M. Brooks, V. B. Koman, S. Yang, X. Gong, T. D. Murphey, M. S. Strano, "Memristor circuits for colloidal robotics: Temporal access to memory, sensing, and actuation." *Advanced Intelligent Systems*, vol. 4, no. 4, 2100205 (2022).
- P. Chvykov, **T. A. Berrueta**, A. Vardhan, W. Savoie, A. Samland, T. D. Murphey, K. Wiesenfeld, D. I. Goldman, J. L. England, "Low rattling: A predictive principle for self-organization in active collectives." *Science*, vol. 371, no. 6524, pp. 90-95 (2021).
- A. T. Taylor, **T. A. Berrueta**, T. D. Murphey, "Active learning in robotics: A review of control principles." *Mechatronics*, vol. 77, 102576 (2021).
- W. Savoie, **T. A. Berrueta**, Z. Jackson, A. Pervan, R. Warkentin, S. Li, T. D. Murphey, K. Wiesenfeld, D. I. Goldman, "A robot made of robots: Emergent transport and control of a smarticle ensemble." *Science Robotics*, vol. 4, no. 34 (2019).
- **T. A. Berrueta**, A. Pervan, K. Fitzsimons, T. D. Murphey, "Dynamical system segmentation for information measures in motion." *IEEE Robotics and Automation Letters*, vol. 4, no. 1, pp. 169-176 (2019).

Conference Papers (* indicates equal authorship)

- A. Pinosky, **T. A. Berrueta**, O. Li, T .D. Murphey, "Physical state exploration for reinforcement learning from scratch." *IEEE International Conference on Automation Science and Engineering (CASE)* (2025).
- S. G. Kumar, J. Ibrahim, **T. A. Berrueta**, S. J. Chung, Fred Y. Hadaegh, "Real-time learning based planning for autonomous rendezvous in space with actuator loss of effectiveness." *AAS Guidance, Navigation & Control Conference (GNC)* (2025).
- **T. A. Berrueta***, A. Q. Nilles*, A. Pervan*, T .D. Murphey, S. M. LaValle, "Information requirements of collision-based micromanipulation." *Proceedings of the Workshop on the Algorithmic Foundations of Robotics (WAFR)* (2020).
- A. Kalinowska, **T. A. Berrueta**, T .D. Murphey, "Data-driven gait segmentation for walking assistance in a lower-limb assistive device." *IEEE International Conference on Robotics and Automation (ICRA)* (2019).

Book Chapters

- **T. A. Berrueta**, I. Abraham, T. D. Murphey, "Experimental applications of the Koopman operator in active learning for control." *The Koopman Operator in Systems and Control*, Springer (2020).

Workshop Papers and Abstracts

- **T. A. Berrueta**, N. Ranganathan, S. J. Chung, "Active learning of tire parameters for high-speed autonomous racing." *Robotics: Science and Systems*, (2025).
- A. T. Taylor, **T. A. Berrueta**, T. D. Murphey, "Emergent mechanism design via robot swarms." *Robotics: Science and Systems*, (2022).
- **T. A. Berrueta**, J. F. Yang, A. M. Brooks, A. T. Liu, M. S. Strano, T. D. Murphey, "Emergent beating in colloidal matter: Stabilization via symmetry breaking." *Bulletin of the American Physical Society*, (2022).
- A. T. Taylor, **T. A. Berrueta**, T. D. Murphey, "Optimizing the locomotion of a robotic active matter system of smarticles." *Bulletin of the American Physical Society*, (2021).
- A. Q. Nilles, A. Pervan, **T. A. Berrueta**, T. D. Murphey, "Controlling active Brownian particles with 'active billiard' particles." *Bulletin of the American Physical Society*, (2020).
- **T. A. Berrueta**, A. Pervan, T. D. Murphey, "Towards robust motion planning for synthetic cells in a circulatory system." *Robotics: Science and Systems*, (2019).

INVITED TALKS

- **T. A. Berrueta**, "Towards transparent & reliable embodied reinforcement learning agents." *Microsoft Future Leaders in Robotics and AI Seminar Series*. University of Maryland, April 26th, 2024, YouTube Video
- **T. A. Berrueta**, "Robot thermodynamics: Making complex systems task-capable." *Gordon Research Conference* (GRC): Complex Active and Adaptive Material Systems, Ventura Beach Marriott, February 1st, 2023.
- **T. A. Berrueta**, "Engineering robotic active matter through nonequilibrium self-organization." *Gordon Research Seminar* (GRS): Emergent Phenomena in Active and Living Materials, Ventura Beach Marriott, January 29th, 2023.
- **T. A. Berrueta**, "Imprecision engineering: Lowering cost while increasing capability." *Presidential Fellows Lecture Series*, Northwestern University, October 20th, 2022.
- **T. A. Berrueta**, "Designing for emergence: Making materials 'robotic' with self-organization." *Center for Robotics and Biosystems Seminar Series*, Northwestern University, June 17th, 2022, YouTube Video.
- **T. A. Berrueta**, "Robot thermodynamics: Analysis, control, and design of complex systems." *Allen Discovery Center Invited Seminar*, Department of Biology, Tufts University, April 26th, 2022.
- **T. A. Berrueta**, "Online learning in physical systems." *SIAM Dynamical Systems*, Symposium on Leveraging Machine Learning for Dynamics and Control, May 26th, 2021, YouTube Video.
- **T. A. Berrueta**, "Low rattling: Predicting driven self-organization." *Center for Robotics and Biosystems Seminar Series*, Northwestern University, December 4th, 2020, YouTube Video.

SERVICE

Reviewer

- *Nature Communications, Nature Scientific Reports, IEEE Transactions on Robotics (T-RO), IEEE Robotics and Automation Letters (RA-L), IEEE Transactions on Control Systems Technology (TCST), IEEE International Conference on Robotics and Automation (ICRA), IEEE International Conference on Automation Science and Engineering (CASE), IEEE International Conference on Intelligent Robots and Systems (IROS), IEEE American Control Conference (ACC).*

TEACHING	**Northwestern University**

Northwestern University

ME455: Active Learning in Robotics   Co-Lecturer (2022, 2023, 2024)
- Invited to lecture for half of the semester's classes.
- Developed brand new lecture content spanning multiple units on topics such as optimal control, information theory, reinforcement learning, CVAEs and other models for perception.

ME314: Theory of Machines - Dynamics   TA (2019), Grader (2018, 2021)
- Lectured large senior-level course ($\sim$70 students) on rigid body dynamics and Lagrangian mechanics.
- Redesigned class content and homeworks as it pivoted to an online-friendly format.

EXPERIENCE

Harvey Mudd College

Kaiam Corporation Capstone   2016-2017
- Designed a MEMS-based laser diode burn-in platform for testing of optical transceivers, which are crucial to data centers worldwide.

Amazon Lab126 Capstone   2016
- Designed a robotic hardware platform for improving the voice-responsiveness of the Amazon Echo.

Northrop Grumman

Control Systems Intern: Survivability Group   2016
- Developed an infrared signature estimator model and worked on algorithms to minimize aircraft IR exposure in real-time.

SpaceX

Vehicle Engineering Intern: Engine Dynamics Group   2014-2015
- Modelled and characterized flight environments experienced by M1D and MVacD rocket engines in order to anticipate design failure modes and ensure mission safety.

LEADERSHIP &
OUTREACH

California Institute of Technology
- Mentor to 6 Ph.D. students and 2 Masters students (2024-current).
- Manager of 2 undergraduate summer research internship projects (2025).

Northwestern University
- Board member of the Northwestern Mechanical Engineering Graduate Student Society (2017-2019).
- Organizer of recruitment activities for incoming mechanical engineering graduate students (2018).
- Mentor to 8 Ph.D. and Masters students through the department mentorship program (2017-2024).
- Volunteer at the Chicago Museum of Science and Industry, teaching members of the public about robots and technology (2017-2024).

Harvey Mudd College
- Member of the Harvey Mudd College Entrepreneurial Network (2017).
- Mentor in the Harvey Mudd College mentorship program (2016-2017).

NOTABLE PRESS
- *Caltech Magazine*, "Computer, Start Your Engine", 2025.
- *ArsTechnica*, "Exploration-focused training lets robotics AI immediately handle new tasks", 2024.
- *Northwestern News*, "This algorithm makes robots perform better", 2024.
- *Northwestern News*, "PhD Student Chosen as a Presenter for the Future Leaders in Robotics and AI Seminar Series", 2024.
- *Northwestern News*, "Chemistry flexes robotic arm without electronics," 2022.
- *MIT News*, "Tiny particles work together to do big things," 2022.
- *Northwestern News*, "Two Graduate Students Receive Presidential Fellowships," 2022.
- *Science Magazine (Podcast)*, "The uncertain future of North America's ash trees, and organizing robot swarms," 2021.
- *Gizmodo*, "Meet the Pint-Sized Robots that Spontaneously Dance," 2020.
- *Popular Mechanics*, "These Robots Literally Just Flap Their Wings. That's It. But the Army Loves Them.," 2019.
- *Scientific American*, "Prehistoric Suckers, Slapping Robots and Three Billion Birds Gone," 2019.
- *Science Magazine (News)*, "Watch a robot made of robots move around," 2019.