

# Thomas A. Berrueta

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EDUCATION	Northwestern University, Evanston, IL Ph.D. Candidate in Mechanical Engineering	Harvey Mudd College, Claremont, CA B.S. Engineering, Graduated with Honors
HONORS	<ul style="list-style-type: none"><li>• Northwestern University Presidential Fellow (highest honor attainable) 2022-2024</li><li>• Schmidt Science Postdoctoral Fellowship Finalist 2023</li><li>• Microsoft Ada Lovelace Fellowship Finalist 2019</li><li>• Walter P. Murphy Fellowship 2017-2018</li><li>• Harvey S. Mudd Merit Scholarship 2013-2017</li><li>• Dean's List 2013-2017</li></ul>	
RESEARCH	<b>Center for Robotics and Biosystems</b> <ul style="list-style-type: none"><li>• I study complex physical systems and their emergent capabilities through the lens of robotics. I look to the physics of self-organization for designing control strategies in settings where most methods fail.</li><li>• I develop algorithms that identify emergent simplicity and discrete structure arising from the interactions of robot swarms, many-body systems, and human-machine systems.</li><li>• I derive techniques that simultaneously leverage modern machine learning, control theory, statistical physics, and information theory towards making complex systems controllable.</li></ul>	
PUBLICATIONS	<i>Journal Papers</i> (* indicates equal authorship) <ul style="list-style-type: none"><li>• J. F. Yang*, <b>T. A. Berrueta*</b>, 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." <i>Nature Communications</i>, vol. 13, 5734, (2022).</li><li>• J. F. Yang, A. T. Liu, <b>T. A. Berrueta</b>, 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." <i>Advanced Intelligent Systems</i>, vol. 4, no. 4, 2100205 (2022).</li><li>• P. Chvykov, <b>T. A. Berrueta</b>, 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." <i>Science</i>, vol. 371, no. 6524, pp. 90-95 (2021).</li><li>• A. Taylor, <b>T. A. Berrueta</b>, T. D. Murphey, "Active learning in robotics: A review of control principles." <i>Mechatronics</i>, vol. 77, 102576, (2021).</li><li>• W. Savoie, <b>T. A. Berrueta</b>, 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." <i>Science Robotics</i>, vol. 4, no. 34 (2019).</li><li>• <b>T. A. Berrueta</b>, A. Pervan, K. Fitzsimons, T. D. Murphey, "Dynamical system segmentation for information measures in motion." <i>IEEE Robotics and Automation Letters</i>, 4 (1), 169-176 (2019).</li></ul> <i>Conference Papers</i> (* indicates equal authorship) <ul style="list-style-type: none"><li>• A. Q. Nilles*, A. Pervan*, <b>T. A. Berrueta*</b>, T. D. Murphey, S. M. LaValle, "Information requirements of collision-based micromanipulation." <i>Proceedings of the Workshop on the Algorithmic Foundations of Robotics (WAFR)</i> (2020).</li><li>• A. Kalinowska, <b>T. A. Berrueta</b>, T. D. Murphey, "Data-driven gait segmentation for walking assistance in a lower-limb assistive device." <i>IEEE International Conference on Robotics and Automation (ICRA)</i> (2019).</li></ul> <i>Book Chapters</i> <ul style="list-style-type: none"><li>• <b>T. A. Berrueta</b>, I. Abraham, T. D. Murphey, "Experimental applications of the Koopman operator in active learning for control." <i>The Koopman Operator in Systems and Control</i>, Springer (2020).</li></ul> <i>Workshop Papers</i> <ul style="list-style-type: none"><li>• J. F. Yang, <b>T. A. Berrueta</b>, A. M. Brooks, A. T. Liu, G. Zhang, S. Yang, V. B. Koman, T. D. Murphey, M. S. Strano, "Emergent microrobotic oscillators via asymmetry-induced order." <i>AICHE Annual Meeting</i> (2022).</li><li>• A. Taylor, <b>T. A. Berrueta</b>, T. D. Murphey, "Emergent mechanism design via robot swarms." <i>Robotics: Science and Systems</i>, (2022).</li><li>• <b>T. A. Berrueta</b>, J. F. Yang, A. M. Brooks, A. T. Liu, M. S. Strano, T. D. Murphey, "Emergent beating in colloidal matter: Stabilization via symmetry breaking." <i>Bulletin of the American Physical Society</i>, (2022).</li></ul>	

- A. 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**, “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](#).

#### EXPERIENCE

##### Northwestern University

ME314: Theory of Machines - Dynamics

Co-teacher (2019), Grader (2018, 2021)

- Lectured large senior-level course (~70 students) on rigid body dynamics and Lagrangian mechanics.
- Redesigned class content and homeworks as it pivoted to an online-friendly format.

##### Harvey Mudd College

Kaia Corporation Capstone

2016-2017

- Designed a MEMS-based laser diode burn-in platform for the testing of optical transceivers, which are crucial to data centers world-wide.
- Implemented embedded temperature and current controllers for the microscopic laser diodes.

Amazon Lab126 Capstone

2016

- Designed a hardware platform for testing the voice-responsiveness of the Amazon Echo in various experimental conditions capable of autonomous maneuvering and obstacle avoidance in rooms.

##### Northrop Grumman

IR and Visual Control Systems Intern: Survivability Group

2016

- Developed an infra-red (IR) signature estimator model for autonomous aircraft control, and developed algorithms that optimize aircraft trajectories to minimize 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

##### 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-current).
- Volunteer at the Chicago Museum of Science and Industry, teaching members of the public about robots and technology (2017-current).

##### Harvey Mudd College

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

## SKILLS

### Technical

- Proficient in Python, C++, and MATLAB.
- Expertise in control theory and analysis of dynamical systems, as well as machine learning, information theory, statistical physics, and optimization.

### Other

- I am fluent in Spanish and English, and conversational in French.
- I have played jazz guitar/bass since 2008.
- I do music composition and production in my spare time.
- I love to run, and ran competitively in an NCAA college track and field team.

## NOTABLE PRESS

- *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.