# Andrew P. Sabelhaus

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## EDUCATION

**PH.D. MECHANICAL ENGINEERING**          University of California, Berkeley
Disseration title (tentative): *Quadruped Robots with Actuated Tensegrity Spines*          Expected May 2019
Disseration Committee: *Alice M. Agogino (Chair), Andrew Packard, Claire Tomlin*

**M.S. MECHANICAL ENGINEERING**          University of California, Berkeley
Thesis: *Mechanism and Sensor Design for SUPERball, a Cable-Driven Tensegrity Robot*          Dec. 2014

**B.S. MECHANICAL ENGINEERING**          University of Maryland, College Park
Minor in Computer Science          May 2012

## GRANTS + FUNDING + AWARDS

4. **NASA Space Technology Research Fellowship.** 4 years. Title: *Trajectory Tracking in Nonlinear, High-Order, Underactuated Robotic Systems.* 2015-2019.

3. **CITRIS Tech for Social Good Development Grant.** Block grant. Title: *Laika, The Robot Transport for Disaster Relief.* University of California Center for Information Technology Research in the Interest of Society (CITRIS), 2018.

2. **Markowski-Leach Scholarship Award.** 4 years (re-awarded after two.) *Awarded to LGBTQ individuals at San Francisco Bay Area institutions who "are likely to make a substantial contribution to society."* 2013-2014, 2016-2018. Currently the only repeated awardee on record.

1. **NSF Graduate Research Fellowship.** National Science Foundation. 2012-2015

   *\*In addition to these independent awards and grants, Drew has assisted in writing three large multiple-PI proposals (NSF), one large single-PI proposal (NASA), and two small single-PI proposals.*

## SELECTED PUBLICATIONS

2. **Model-Predictive Control of a Flexible Spine Robot.** Sabelhaus, A.P.; Akella, A.K.; Ahmad, Z.A.; SunSpiral, V.; *American Control Conference (ACC),* May 2017.

1. **System Design and Locomotion of SUPERball, an Untethered Tensegrity Robot.** Sabelhaus, A.P.; Bruce, J.; Caluwaerts, K.; Manovi, P.; Fallah Firoozi, R.; Dobi, S.; Agogino, A.M.; SunSpiral, V.; *IEEE International Conference on Robotics and Automation (ICRA),* May 2015.

## ALL PEER-REVIEWED PUBLICATIONS

10. **Modular Elastic Lattice Platform for Rapid Prototyping of Tensegrity Robots.** Chen, L-H.; Daly, M.C.; Sabelhaus, A.P.; Janse van Vuuren, L.A.; Garnier, H.J.; Verdugo, M.I.; Tang, E.; Spangenberg, C.U.; Ghahani, F.; Agogino, A.K.; Agogino, A.M.; *ASME International Design Engineering Technical Conferences (IDETC) / 41st Mechanisms and Robotics Conference,* Aug 2017.

9. **Model-Predictive Control of a Flexible Spine Robot.** Sabelhaus, A.P.; Akella, A.K.; Ahmad, Z.A.; SunSpiral, V.; *American Control Conference (ACC),* May 2017.

8. **DNA-Structured Linear Actuators.** Zampaglione, K.; Sabelhaus, A.P.; Chen, L.; Agogino, A.M.; Agogino, A.K.; *ASME International Design Engineering Technical Conferences (IDETC) / 40th Mechanisms and Robotics Conference,* Aug 2016.

7. **Mechanism Design and Simulation of the ULTRA Spine, a Tensegrity Robot.** Sabelhaus, A.P.; Ji, H.; Hylton, P.; Madaan, Y.; Yang, C.; Friesen, J.; SunSpiral, V.; Agogino, A.M.; *ASME International Design Engineering Technical Conferences (IDETC) / 39th Mechanisms and Robotics Conference,* Aug 2015.

6. System Design and Locomotion of SUPERball, an Untethered Tensegrity Robot. Sabelhaus, A.P.; Bruce, J.; Caluwaerts, K.; Manovi, P.; Fallah Firoozi, R.; Dobi, S.; Agogino, A.M.; SunSpiral, V.; *IEEE International Conference on Robotics and Automation (ICRA)*, May 2015.

5. Design and Control of Compliant Tensegrity Robots through Simulation and Hardware Validation. Caluwaerts, K.; Despraz, J.; Iscen, A.; Sabelhaus, A.P.; Bruce, J.; Schrauwen, B.; SunSpiral, V.; *Journal of the Royal Society Interface*, Sept. 2014.

4. Hardware Design and Testing of SUPERball, a Modular Tensegrity Robot. Sabelhaus, A.P.; Bruce, J.; Caluwaerts, K.; Chen, Y.; Lu, D.; Liu, Y.; Agogino, A.K.; SunSpiral, V.; Agogino, A.M.; *The 6th World Conference on Structural Control and Monitoring (6WCSCM)*, July 2014

3. SUPERball: Exploring Tensegrities for Planetary Probes. Bruce, J.; Sabelhaus, A.P.; Chen, Y.; Lu, D.; Morse, K.; Milam, S.; Caluwaerts, K.; Agogino, A.M.; SunSpiral, V.; *12th International Symposium on Artificial Intelligence, Robotics, and Automation in Space (i-SAIRAS)*, June 2014

2. Design and Evolution of a Modular Tensegrity Robot Platform. Bruce, J.; Caluwaerts, K.; Iscen, A.; Sabelhaus, A.P.; SunSpiral, V.; *IEEE International Conference on Robotics and Automation (ICRA)*, May 2014

1. TinyTeRP: A Tiny Terrestrial Robotic Platform with Modular Sensing. Sabelhaus, A.P.; Mirsky, D.; Hill, L.M.; Bergbreiter, S.; *IEEE International Conference on Robotics and Automation (ICRA)*, May 2013

## WORKSHOP PUBLICATIONS

2. Inverse Kinematics for Control of Tensegrity Soft Robots: Existence and Optimality of Solutions. Sabelhaus, A.P.; Agogino, A.K.; *IEEE/RSJ International Conference on Intelligent Robots and Systems: Workshop on Soft Robotic Modeling and Control*, To appear, Oct. 2018. Available, arXiv:1808.08252

1. Trajectory Tracking Control of a Flexible Spine Robot, With and Without a Reference Input. Sabelhaus, A.P.; Zhao, S.H.; Daly, M.C.; Tang, E.; Zhu, E.; Akella, A.K.; Ahmad, Z.A.; SunSpiral, V.; Agogino, A.M.; *NASA/ESA Conference on Adaptive Hardware and Systems: Structurally Adaptive Tensegrity Robots Workshop*, July 2017. Available, arXiv:1808.08309

## PRE-PRINTS + PUBLICATIONS UNDER REVIEW

2. Model-Predictive Control with Reference Input Tracking for Tensegrity Spine Robots. Sabelhaus, A.P.; Zhao, H.; Zhu, E.; Agogino, A.K.; Agogino, A.M.; *Under Review (Journal.)* Preprint available, arXiv:1806.08868

1. Design, Simulation, and Testing of a Flexible Actuated Spine for Quadruped Robots. Sabelhaus, A.P.; Janse van Vuuren, L.A.; Joshi, A.; Zhu,E.; Garnier, H.J.; Sover, K.A.; Navarro, J.; Agogino, A.K.; SunSpiral, V.; Agogino, A.M.; *Under review (Conference.)* Preprint available, arXiv:1804.06527

## IN-PREPARATION PUBLICATIONS

3. Slack Cables in Cable-Driven Robots: Modeling and Passivity-Based Control. Sabelhaus, A.P. et al.

2. DNA-Structured Linear Actuators: Modeling and Experimental Characterization. Sabelhaus, A.P.; Tang, E.; Zampaglione, K.; Agogino, A.M.

1. Quadruped Robot Spines Require Torsion for Foot-Lifting. Sabelhaus, A.P. et al.

## PATENTS

2. DNA Structured Linear Actuator. Agogino, A.; Zampaglione, K.; Chen, L-H.; Sabelhaus, A.; US Patent Application Number: PCT/US2016/032899. Under Review.

1. Elastic Lattices for Design of Tensegrity Structures and Robots. Chen, L-H.; Agogino, A.; Daly, M.; Sabelhaus, A.P.; Agogino, A.K.; Provisional Patent.

# PRESENTATIONS + POSTERS

8. **Laika, The Four-Legged Robot with a Flexible Spine.** NASA Space Tehnology Day-On-The-Hill, Nov. 2017. Poster, presented to the United States Congress / U.S. House of Representatives.

7. **Laika, The Quadruped Robot with a Tensegrity Spine.** Bay Area Robotics Symposium (BARS), Oct. 2017. Presentation and Poster.

6. **UC Berkeley Robotics for Disaster Relief.** Field Innovation Team Bootcamp 5.0, March 2017. Presentation.

5. **DNA-Structured Linear Actuators.** SKTA Innopartners IP Redux Event, Apr 2016. Presentation.

4. **ULTRA Spine Project.** Bay Area Robotics Symposium (BARS), Oct 2015. Presentation and Poster.

3. **Robotics, Mechatronics, and Intelligent Systems.** Osher Lifelong Learning Institute, Feb 2014. Invited Talk.

2. **Mechatronic Design of Tensegrity Robotic Systems for Dynamic Locomotion.** NASA Ames Research Center Autonomous Systems Lab Poster Symposium, Aug 2013. Poster.

1. **TinyTeRP: A Tiny Terrestrial Robotic Platform.** International Symposium on Distributed Autonomous Robotic Systems (DARS), Nov 2012. Poster.

# RELEVANT WORK EXPERIENCE

**Visiting Technologist.** NASA Ames Research Center, Intelligent Systems Division.
2015 - Present | Moffett Field, CA
- Developed hardware prototypes, using novel fabrication tehniques, for tensegrity spine robots
- Designed and simulated model-predictive controllers for tensegrity spine robots
- Wrote and maintained components of the NASA Tensegrity Robotics Toolkit in C++
- Tested and verified model validity of a tensegrity spine within a quadruped robot
- Created framework for asymptotically-stable closed-loop controllers for cable-driven robots using passivity

**Graduate Student Researcher.** NASA Ames Research Center, Intelligent Robotics Group.
2013 - 2014 | Moffett Field, CA
- Designed, prototyped, and tested mechanisms of SUPERball, an autonomous tensegrity robot, including the cable driving system, actuation system, and active-compliance spring system
- Designed, tested, calibrated, and assembled custom force sensors for SUPERball
- Demonstrated first prototype locomotion of SUPERball, providing proof-of-concept of a full-scale spherical tensegrity robot in rolling motion

# REVIEWER FOR JOURNALS AND CONFERENCES

Drew has served as a reviewer for the following journals and conferences:

- IEEE Robotics and Automation Magazine, 2018
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018.
- IEEE Robotics and Automation Letters (RA-L), 2017, 2018
- IEEE International Conference on Robotics and Automation (ICRA), 2017.
- American Control Conference (ACC), 2017-2018.
- ASME International Design Engineering Technical Conference (IDETC), 2016-2017.
- International Journal of Space Structures, 2017.
- IEEE Conference on Control Technology and Applications (CCTA), 2017.

# TEACHING

**Graduate Student Instructor (GSI).** University of California, Berkeley.
Jan. - May, 2018 | Mech. Eng. 135/235, Design of Microprocessor-Based Mechanical Systems
- Created course content for lab and discussion sections, delivered stand-in lectures, assisted students with projects.
- Overall Course Evaluations: *Total Effectiveness of Instructor: 4.7/5.0 (Undergrad.), 4.88/5.0 (Grad.)*
- Teaching evaluations were above department averages in every metric.

# MENTORSHIP + ADVISING

Drew has officially mentored the following students through UC Berkeley's Undergraduate Research Apprenticeship Program (URAP) and the Master of Engineering (M.Eng) program:

**Graduate Student Researchers:**
- Holly Stein, M.Eng 2018
- Nigel Mevana, M.Eng 2018
- Jonathan Marr, M.Eng 2018
- Lara Janse van Vuuren, M.Eng 2017
- Shirley (Huajing) Zhao, M.Eng 2017
- Robel Teweldebirhan, M.Eng 2017
- Asher Saghian, M.Eng 2017
- June (Shu Jun) Tan, M.Eng 2017
- Kyle Zampaglione (project mentoring), M.S. 2015
- Patrick Hylton, M.Eng 2015
- ChanWoo Yang, M.Eng 2015
- Yakshu Madaan, M.Eng 2015
- Yangxin Chen, M.Eng 2014
- Dizhou Lu, M.Eng 2014
- Margaret (Yuejia) Liu, M.Eng 2014

**Undergraduate Student Researchers:**
- Angela Wang, B.S. 2020
- Kimberly Sover, B.S. 2019
- Jesus Navarro, B.S. 2018
- Lua Varner, B.S. 2018
- Hunter Garnier, B.S. 2018
- Akhilesh Mishra, B.S. 2018
- Ankita Joshi, B.S. 2017
- Jorge Vizcayno, B.S. 2016
- Heeyeon Kwon, B.S. 2016
- Zeerek Ahmad, B.S. 2015
- Sarah Dobi, B.S. 2015
- Roya Fallah Firoozi, B.S. 2014

# DIVERSITY + OUTREACH + SERVICE

- **ASME Diversity and Inclusion Strategic Commitee (DISC), Advisor.** American Society of Mechanical Engineers (ASME). Revised ASME policy P-15.11, PS16-02, and Statement on Diversity and Inclusion to include protections for transgender ASME members. June 2016 - Ongoing.

- **ASEE LGBTQ Virtual Community of Practice, Member.** American Society for Engineering Education. Organizing for LGBTQ safe space workshops in engineering. March 2018 - Ongoing.

- **Graduate Student Search Committee, Member.** UC Berkeley Mechanical Engineering Faculty Searches. Led committee in interviewing and recommending faculty candidates. Spring 2017 - Spring 2018.

- **Graduate Peer Advisor.** UC Berkeley Mechanical Engineering - Equity, Diversity, and Inclusion Initiative. Created and assessed various programs serving under-represented students. Aug 2014 - May 2015.

- **Coordinator, Chapter Leadership Programs.** Out in Science, Technology, Engineering, and Mathematics (oSTEM) Incoporated. Led team in developing resources for LGBTQ student leaders. July 2012 - April 2013.

  *In addition to these formal programs, Drew has organized many lab tours and smaller outreach events, and has volunteered with programs that recruit under-represented students to UC Berkeley.*

# PROFESSIONAL DEVELOPMENT

- **Summer Institute for Preparing Future Faculty.** A professional development program to prepare students for academic careers. University of California, Berkeley. Completed / certified in June 2018.

- **Question, Persuade, Refer: Gatekeeper.** Trained for response to mental health crises in students. University of California Berkeley Health Center, March 2018.

- **Teaching of Mechanical Engineering at the University Level.** UC Berkeley Mechanical Engineering Department. Course on teaching pedagogy in engineering. Spring 2018.

- **Workshops on Teaching and Learning.** UC Berkeley GSI Teaching and Resource Center / Academic Innovation Studio. Attended workshops on teaching pedagogy, including `How Students Learn' and `Teaming With Diversity.' Fall 2017 - Spring 2018.

- **Teaching Conference for Graduate Student Instructors.** UC Berkeley GSI Teaching and Resource Center. Introductory pedagogy for first-time Graduate Student Instructors. Attended in Jan. 2018.