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Aaron Hoover

Asst. Prof. of Mechanical Engineering

Education

2010 **PhD Mechanical Engineering**, *University of California, Berkeley*.

2006 **MSc Mechanical Engineering**, *University of California, Berkeley*.

1999 **BSc - Mechanical Engineering**, *Stanford University*.

PhD Dissertation

title *Design of Minimally Actuated Legged Milli-Robots Using Compliant Mechanisms and Folding*

supervisor Ronald Fearing

description Designed and developed a process for scaled prototyping of millimeter scale robots (millirobots) that uses origami-style folding techniques, compliant flexure hinges, and parallel kinematic mechanisms. Proposed collapsing a formulation of equivalent mechanism compliance to a single strain energy-based scalar metric using screw theory to predict mechanism performance. Demonstrated two legged robot designs - a millimeter scale (2.4g), quasi-static hexapedal robot and another scale prototype dynamic legged robot capable of running approximately 14 body-lengths per second.

Master's thesis

title *Design, Prototyping, and Testing of a Low Cost 2 Axis Micropositioning Stage Using Compliant Mechanisms*

supervisor Ronald Fearing

description Designed, fabricated, and characterized an ultra low-cost micropositioning stage based on large displacement compliant mechanisms. Combining the stage with a commercial, off-the-shelf digital microscope camera enabled calibration and visual servoing using basic computer vision techniques. The stage demonstrated sub-100 micron resolution.

Postdoctoral Experience

2010 **Postdoctoral Researcher**, *University of California, Berkeley*.
Developed embedded software for sensing, control, planning, and wireless communication on a 5.5g centimeter scale, power-autonomous legged robot.

Teaching Experience

Courses Taught at Olin College

2015, 2016 **Products and Markets (AHSE1515)**, The aim of this course is to give students a set of learning experiences explicitly focused on the idea of engaging in creative enterprise for the good of the world. By pursuing the creation of real enterprises, our hope is that students will come to a deeper understanding and appreciation of the role that business and entrepreneurship play in realizing change. Special focus is placed on identifying opportunities provided by an entrepreneurial framework, the role of entrepreneurship in pursuing value, and the routes to making change in the world. Traditional definitions of engineering lack sufficient consideration of the personal, market, and organizational realities that must be addressed to effectively and sustainably deliver value to the world. This course is a first step in exposing and addressing these critical perspectives and skills. In this course students strive to create real enterprises. They learn to imagine personally relevant ways to create value for others, develop focused hypotheses to test these value propositions, devise experiments to test these propositions, and use this learning to evolve and realize their vision.

2014 - 2016 **Elecanisms (Mechatronics) (ENGR3199)**, This course involves the synergistic integration of mechanical engineering with electronics and intelligent computer control in the design of products. In this course, we develop topics critical to the engineering of modern mechatronic systems including electromechanical actuators (e.g., DC motors, stepper motors, and solenoids), practical electronics design including interfacing sensors and actuators to embedded processors, and embedded software design in the C programming language. During the first part of the course, students work in small groups on a series of miniprojects to gain experience with course concepts and develop core engineering competencies. During the second part of the course, students work in teams to engineer a mechatronic system of their choosing subject to realistic constraints.

2012 **Dynamics (ENGR2340)**, A required course for all mechanical engineering majors at Olin, this course covers topics in kinematics and dynamics of particles and rigid bodies as well as linear dynamical systems. Students learn to formulate and solve equations of motion for particles, rigid bodies, and systems of each. A significant portion of the course is devoted to numerical simulation of equations of motion and visualization applied to problems like determining stable parameters for a model of legged locomotion or chaotic parameters an initial conditions for simple systems like the double pendulum.

2012 **Senior Capstone Project in Engineering (ENGR4190)**, SCOPE is a year-long senior capstone project in which a team of five to six undergraduate students and a faculty advisor work with an industry sponsor to deliver a solution to a real world engineering problem. Students perform all aspects of the project including budgeting, managing interactions with the sponsor liaison, project planning and schedule development, technical work, and written and oral communication of results.

Teams Advised:

- **MIT Lincoln Laboratory (2011 - 2012)** - "A Hybrid Aerial Underwater Vehicle"
- **Ariens (2012 - 2013)** - "Traction Control Systems for Commercial Lawn Mowers"
- **Brandeis University (2013-2014)** - "Rapid Prototyping Microfluidic Foil Chips"

2011, 2013, 2014 **Introduction to Mechanical Prototyping (ENGR2330)**, An elective course available and accessible to all Olin, Babson, and Wellesley students. The course is an introduction to the design and physical prototyping of mechanical systems of moderate complexity. Students get experience communicating mechanical designs using 3-dimensional models in computer-aided design (CAD) software as well as traditional 2-dimensional engineering drawings.Throughout the course, students complete a series of hands-on projects designed to provide them with experience prototyping machines and mechanisms in materials ranging from foamcore and plywood to sheet metal and 3-D printed polymers. Sample work can be found online at http://mechproto.olin.edu.

2011, 2012, 2014, 2015 **Principles of Engineering (ENGR2210)**, Sophomore level course required for all Olin students in which they're introduced to mechatronic systems. Topics covered include programming Arduino microcontrollers in the C/C++ programming language, interfacing with additional hardware such as motors, sensors, and a host computer. Students complete projects comprising a combination of non-trivial mechanical, electrical, and software systems in groups of two to five. The course is exclusively hands-on and includes very few lectures and no required text. Sample projects from past offerings can be found at http://poe.olin.edu.

2011 **Controls - Theory and Practice (ENGR3370)**, Junior/senior level elective course introducing fundamental concepts in modeling and control of single-input, single-output (SISO) linear, time-invariant (LTI) systems. Topics covered include state space modeling of linear dynamical systems, Laplace transforms, root locus, Bode plots, frequency domain analysis, and PID and lead-lag controller design techniques. Students complete a group project that includes the implementation of a control strategy on hardware of their choice at the end of the class.

Teaching experiences prior to Olin College

2007 **Graduate Student Instructor - E28 Introduction to Engineering Graphics**, *University of California, Berkeley*.

2006, 2007 **Graduate Student Mentor - Summer Undergraduate Program in Engineering Research at Berkeley (SUPERB)**, *University of California, Berkeley*.

2006 **Graduate Student Mentor - University of California's Leadership Excellence through Advanced Degrees (UC LEADS)**, *University of California, Berkeley*.

1999 **Team Coach - ME 118/218 Introduction to Mechatronics**, *Stanford University*.

Advising and Consulting

2013 - Present **Technical advisor and mentor to founding team at Dash Robotics, makers of Kamigami Robots**.

Publications

Peer-Reviewed Journal Papers

[1] Dennis Evangelista, María José Fernández, Madalyn S Berns, Aaron Hoover, and Robert Dudley. Hovering energetics and thermal balance in annaÊijs hummingbirds (calypte anna). *Physiological and biochemical zoology PBZ*, 83(3):406–413, 2010.

[2] Jean-Michel Mongeau, Brian McRae, Ardian Jusufi, Paul Birkmeyer, Aaron M. Hoover, Ronald Fearing, and Robert J. Full. Rapid inversion: Running animals and robots swing like a pendulum under ledges. *PLoS ONE*, 7(6):e38003, 06 2012.

[3] A. Vijayaraghavan, A. Sodemann, A. M. Hoover, J. R. Mayor, and D. Dornfeld. Trajectory generation in high-speed, high-precision micromilling using subdivision curves. *Int. J. Mach. Tools Manuf.*, 50(4):394 – 403, 2010. <ce:title>Design of Ultraprecision and Micro Machine Tools and their Key Enabling Technologies</ce:title>.

[4] Athulan Vijayaraghavan, Aaron M. Hoover, Jeffrey Hartnett, and David A. Dornfeld. Improving endmilling surface finish by workpiece rotation and adaptive toolpath spacing. *International Journal of Machine Tools and Manufacture*, 49(1):89 – 98, 2009.

[5] Tingnan Zhang, Feifei Qian, Chen Li, Pierangelo Masarati, Aaron M. Hoover, Paul Birkmeyer, Andrew Pullin, Ronald S. Fearing, and Daniel I. Goldman. Ground fluidization promotes rapid running of a lightweight robot. *The International Journal of Robotics Research*, 32(7):859–869, 2013.

Peer-Reviewed Conference Papers

[6] S. S. Desai, A. M. Eckert-Erdheim, and A. M. Hoover. A large-area tactile force sensor for measuring ground reaction forces from small legged robots. In *Intelligent Robots and Systems (IROS), 2013 IEEE/RSJ International Conference on*, pages 4753–4758, 2013.

[7] A. M. Hoover, S. Burden, X. Y. Fu, S. Shankar Sastry, and R. S. Fearing. Bio-inspired design and dynamic maneuverability of a minimally actuated six-legged robot. In *IEEE Int. Conf. on Biomedical Robotics and Biomechatronics (BioRob)*, pages 869–876, 2010.

[8] A. M. Hoover and R. S. Fearing. Rapidly prototyped orthotweezers for automated microassembly. In *IEEE Int. Conf. on Robotics and Automation*, Rome, Italy, 2007.

[9] A. M. Hoover and R. S. Fearing. Fast scale prototyping for folded millirobots. In *IEEE Int. Conf. on Robotics and Automation*, Pasadena, CA, 2008.

[10] A. M. Hoover, E. Steltz, and R. S. Fearing. RoACH: An autonomous 2.4g crawling hexapod robot. In *IEEE Int. Conf. on Intelligent Robots and Systems*, Nice, France, Sept. 2008.

[11] A.M. Hoover and R.S. Fearing. Analysis of off-axis performance of compliant mechanisms with applications to mobile millirobot design. In *Intelligent Robots and Systems, 2009. IROS 2009. IEEE/RSJ International Conference on*, pages 2770 –2776, oct. 2009.

[12] N. J. Kohut, A. M. Hoover, K. Ma, S. Baek, and R. S. Fearing. Medic: A 5.5g legged millirobot utilizing novel body-supported climbing. In *IEEE Int. Conf. on Robotics and Automation*, 2011.

[13] Feifei Qian, Tingnan Zhang, chen Li, Aaron Hoover, Pierangelo Masarati, Paul Birkmeyer, Andrew Pullin, Ronald Fearing, and Dan Goldman. Walking and running on yielding and fluidizing ground. In *Proceedings of Robotics: Science and Systems*, Sydney, Australia, July 2012.

[14] Gray C. Thomas, Clayton C. Gimenez, Erica D. Chin, Andrew P. Carmedelle, and Aaron M. Hoover. Controllable, high force amplification using elastic cable capstans. In *ASME IDETC/CIE*, Chicago, IL, Aug. 2012. ASME.

Conference Papers

[15] Robert Full, Kaushik Jayaram, Jean-Michel Mongeau, Paul Birkmeyer, Aaron Hoover, and Ronald Fearing. The role of robustness in running: Bio- and bio-inspired exoskeletons. In *Society of Integrative and Comparative Biology Annual Meeting*, Salt Lake City, 5 January 2011.

[16] Chen Li, Aaron M. Hoover, Paul Birkmeyer, Paul B. Umbanhowar, Ronald S. Fearing, and Daniel I. Goldman. Systematic study of the performance of small robots on controlled laboratory substrates. In *Micro- and Nanotechnology Sensors, Systems, and Applications II, Proc of the SPIE Conf on*, pages 76790Z–76790Z–13. SPIE, April 2010.

[17] Feifei Qian, Tingnan Zhang, Chen Li, Aaron M. Hoover, Paul Birkmeyer, Andrew Pullin, Ronald S. Fearing, Daniel I. Goldman, and Pierangelo Masarati. Legged locomotion of a bio-inspired lightweight robot on granular media. In *Integrative and Comparative Biology*, 2012.

Poster Presentations

[18] Gray Thomas, Clayton C. Gimenez, Andrew P. Carmedelle, Erica D. Chin Chin*, and Aaron M. Hoover Woburn. Using a capstan cable-drive actuator under helical constraint to achieve high amplification ratios. In *IEEE International Conference on Technologies for Practical Robot Applications (TePRA)*, Woburn, MA, April 2012.

Service to Olin College

2015-2016 **Strategic Fabrication and Facilities Committee**, *chair*.
Library Committee, *co-chair*.

2014-2015 **Strategic Fabrication and Facilities Committee**, *chair*.
Human Powered Vehicles team, *faculty co-advisor*.

2013-2014 **Strategic Fabrication and Facilities Committee**, *chair*.
Curriculum Innovation Committee, *member*.

Human Powered Vehicles team, *faculty co-advisor*.

2012-2013 **Academic Recommendation Board**, *member*.

Faculty Search Committee, *member*.

Human Powered Vehicles team, *faculty co-advisor*.

2011-2012 **Committee on Curricular Effectiveness**, *member*.

Human Powered Vehicles team, *faculty co-advisor*.

2010-2011 **SAE Mini-Baja team**, *faculty advisor*.

Professional Service

Reviewer for *Autonomous Robots*.

Reviewer for *Mechatronics Forum International Conference*.

Reviewer for *Biology Letters*.

Reviewer for *International Journal of Precision Engineering and Manufacturing*.

Member IEEE Robotics and Automation Society Technical Committee on BioRobotics.

Reviewer for *IEEE/ASME Transactions on Mechatronics*.

Reviewer for *IEEE Transactions on Robotics*.

Reviewer for *Institute of Physics Journal of Micromechanics and Microengineering*.

Reviewer for *Robotica*.

2010 **Co-chair Animal and Robot Session, IEEE International Conference on Biomedical Robotics and Biomechatronics (BIOROB)**, *Tokyo, Japan*.

2009 **Co-chair Millirobots Session, IEEE International Conference on Intelligent Robots and Systems**, *St. Louis, MO*.

2008 **Co-chair Micro/Nano Robotics Session, IEEE International Conference on Intelligent Robots and Systems**, *Nice, France*.

2006-Present **Member, IEEE**.

2006-Present **Member, ASME**.

Media Coverage

2016 **"Olin college students create machine that makes pancakes"**, *Boston Globe*, Article in the Boston Globe about a final project for ENGR2210 - Principles of Engineering.

2012 **"At Olin Students Get a Grasp on Engineering"**, *Needham Times*, Article in the Needham Times about ENGR2330 - Introduction to Mechanical Prototyping final competition in which students compete to design and demonstrate capable robotic hands..

2009 **Catalyst - Robot Biomimicry**, *Australian Broadcasting Corporation*, Television feature on bio-inspired robotics.

2008 **"Robots" podcast**, *Ecole Polytechnique Fédérale de Lausanne*, Jumping and crawling in millirobots.

Honors and Awards

2013 **Invited to National Academy of Engineering Frontiers of Engineering Education (FOEE) symposium**.

2009 **1st Place - ASME Student Robot Design Competition**, *"RoACH: An autonomous 2.4g crawling robot"*, IDETC, San Diego, CA.

2009 **Fellow of the Berkeley Summer Institute for Preparing Future Faculty**.

2008 **ICROS Best Application Paper Award Finalist**, *"RoACH: An autonomous 2.4g crawling robot"*, IEEE Conference on Intelligent Robots and Systems, Nice, France.