

Jonathan W. Hurst

Contact Information

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Current Position

Associate Professor, College of Engineering Dean's Professor
Collaborative Robotics and Intelligent Systems Institute
Oregon State University, Corvallis, Oregon

Chief Technology Officer
Agility Robotics, Albany, Oregon

Education

Carnegie Mellon University, Pittsburgh, Pennsylvania USA
Ph.D., Robotics, August 12, 2008
Dissertation Topic: "The Role of Compliance in Legged Locomotion."
Advisor: Jessica K. Hodgins
Thesis Committee: Matthew T. Mason
Alfred A. Rizzi
J. Kenneth Salisbury

M.S., Robotics, May 2004
Advisor: Alfred A. Rizzi

B.S., Mechanical Engineering, Minor in Robotics, May 2001

Journal Publications

Christian Hubicki, Jesse Grimes, Mikhail Jones, Daniel Renjewski, Alexander Spröewitz, Andy Abate, and Jonathan Hurst, "ATRIAS: Design and Validation of a Tether-free 3D-capable Spring-Mass Bipedal Robot," *International Journal of Robotics Research*, 2016, Vol. 35(12) 1497-1521

Daniel Renjewski, Alexander Sproewitz, Andrew Peekema, Mikhail Jones, and Jonathan W. Hurst, "Exciting Engineered Passive Dynamics in a Bipedal Robot," *IEEE Transactions on Robotics*, Vol. 31, Issue 5, October 2015

Aleksandra V. Birn-Jeffery*, Christian M. Hubicki*, Yvonne Blum, Daniel Renjewski, Jonathan W. Hurst, and Monica A. Daley, "Don't Break a Leg: Running Birds from Quail to Ostrich Prioritise Leg Safety and Economy on Uneven Terrain," *Journal of Experimental Biology*, 217, 3786-3796. Featured Article. *Authors contributed equally to the manuscript. Article is available open-access at <http://jeb.biologists.org/>

Yvonne Blum, Hamid R. Vejdani, Aleksandra V. Birn-Jeffery, Christian M. Hubicki, Jonathan W. Hurst, and Monica A. Daley, "Swing-Leg Trajectory of Running Guinea Fowl Suggests Task-Level Priority of Force Regulation Rather than Disturbance Rejection," *PlosOne*, DOI: 10.1371/journal.pone.0100399 The final publication is available at <http://www.plosone.org>

H.R. Vejdani, Y. Blum, M.A. Daley, and J.W. Hurst, "Bio-inspired swing leg control for spring-mass robots running on ground with unexpected height disturbance," *Bioinspiration & Biomimetics* (DOI: 10.1088/1748-3182/8/4/046006), 2013

D. Koepl and J.W. Hurst, "Impulse Control for Planar Spring-Mass Running," *Journal of Intelligent*

and Robotic Systems (DOI: 10.1007/s10846-013-9877-8), 2013

A. Ramezani, J.W. Hurst, J.W. Grizzle, “Performance Analysis and Feedback Control of ATRIAS, A 3D Bipedal Robot,” *Journal of Dynamic Systems, Measurement and Control*, accepted May 2013

Y. Blum, C. Hubicki, H. Vejdani, J.W. Hurst, M. Daley, “Trade-off Between Disturbance Rejection and Injury Avoidance in Running Guinea Fowl,” Submitted to *Public Library of Science One*, accepted pending revision May 2013

K. Kemper, H. R. Vejdani, B. Piercy, J. Hurst, “Optimal Passive Dynamics for Physical Interaction: Catching a Mass,” *Actuators* 2013, 2(2), 45-58, May 2013

J.S. Colett and J.W. Hurst, “Artificial Restraint Systems for Walking and Running Robots: An Overview,” *International Journal of Humanoid Robotics*, Vol. 09, Issue 01, March 2012.

J.W. Hurst, “The Electric Cable Differential Leg: A Novel Design Approach for Walking and Running,” *International Journal of Humanoid Robotics*, Vol. 8, Issue 2, 301-321, June 2011.

H.W. Park, K. Sreenath, J.W. Hurst, J.W. Grizzle, “Identification of a Bipedal Robot with a Compliant Drivetrain: Parameter Estimation for Control Design,” *IEEE Control Systems Magazine*, Vol 31, Issue 2, April 2011 (cover story).

J.W. Hurst, J.E. Chestnutt, and A.A. Rizzi, “The Actuator with Mechanically Adjustable Series Compliance,” *IEEE Transactions on Robotics*, Vol. 26, No. 4, September 2010.

J.W. Hurst and A.A. Rizzi, “Series Compliance for an Efficient Running Gait: Lessons Learned from the Electric Cable Differential Leg,” *IEEE Robotics and Automation Magazine*, Special Issue: “Adaptable Compliance / Variable stiffness for Robotic Applications,” Vol. 15, Issue 3, September 2008, pages 42-51.

Conference Publications

Andy Abate, Jonathan W. Hurst, and Ross L. Hatton, “Mechanical Antagonism in Legged Robots,” *Robotics Science and Systems (RSS)*, June 2016

Siavash Rezazadeh, Christian Hubicki, Mikhail Jones, Andrew Peekema, Johnathan Van Why, Andy Abate and Jonathan W. Hurst, “Spring-mass Walking with ATRIAS in 3D: Robust Gait Control Spanning Zero to 4.3 KPH on a Heavily Underactuated Bipedal Robot,” *ASME Dynamic Systems and Control Conference (DSCC)*, October 2015

Hamid Vejdani, Albert Wu, Hartmut Geyer, and Jonathan W. Hurst, “Touch-down Angle Control for Spring-Mass Walking,” *IEEE International Conference on Robotics and Automation (ICRA)*, May 2015

Siavash Rezazadeh and Jonathan W. Hurst, “Toward Step-by-Step Synthesis of Stable Gaits for Underactuated Compliant Legged Robots,” *IEEE International Conference on Robotics and Automation (ICRA)*, May 2015

Christian Hubicki, Mikhail Jones, Monica A. Daley, Jonathan W. Hurst, “Do Limit Cycles Matter in the Long Run? Stable Orbits and Sliding-Mass Dynamics Emerge in Task-Optimal Locomotion,” *IEEE International Conference on Robotics and Automation (ICRA)*, May 2015

Ayonga Hereid, Christian Hubicki, Eric Cousineau, Jonathan W. Hurst, and Aaron D. Ames, “Hybrid Zero Dynamics based Multiple Shooting Optimization with Applications to Robotic Walking,” *IEEE International Conference on Robotics and Automation (ICRA)*, May 2015

Siavash Rezazadeh and Jonathan W. Hurst, "On The Optimal Selection of Motors and Transmissions for Electromechanical and Robotic Systems," IEEE International Conference on Intelligent Robots and Systems (IROS) (10.1109/IROS.2014.6943215), Sept. 2014.

Behnam Dadashzadeh, Hamid R. Vejdani, and Jonathan Hurst, "From Template to Anchor: A Novel Control Strategy for Spring-Mass Running of Bipedal Robots," IEEE International Conference on Intelligent Robots and Systems (IROS) (10.1109/IROS.2014.6942912), Sept. 2014.

A. Hereid, S. Kolathaya, M.S. Jones, J.R. Van Why, J.W. Hurst, and A.D. Ames, "Dynamic Multi-Domain Bipedal Walking with ATRIAS through SLIP based Human-Inspired Control," Hybrid Systems and Control Conference (HSCC) (DOI: 10.1145/2562059.2562143), April 2014

A. Peekema, D. Renjewski and J.W. Hurst, "Open-Source Real-Time Robot Operation and Control System for Highly Dynamic, Modular Machines," ASME International Design Engineering Technical (IDET), August 2013.

H.R. Vejdani, J.W. Hurst, "Optimal Passive Dynamics for Physical Interaction: Throwing a Mass," IEEE Conference on Robotics and Automation (ICRA), May 2013

J.A. Grimes and J.W. Hurst, "The Design of ATRIAS 1.0: A Unique Monopod, Hopping Robot" (**Awarded Best Technical Paper**), International Conference on Climbing and Walking Robots (CLAWAR), July 2012.

C.M. Hubicki and J.W. Hurst, "Running on Soft Ground: Simple, Energy-Optimal Disturbance Rejection," International Conference on Climbing and Walking Robots (CLAWAR), July 2012.

H.R. Vejdani and J.W. Hurst, "Swing Leg Control for Actuated Spring-Mass Robots," International Conference on Climbing and Walking Robots (CLAWAR), July 2012.

M.S. Jones and J.W. Hurst, "Effects of Leg Configuration on Running and Walking Robots," International Conference on Climbing and Walking Robots (CLAWAR), July 2012.

D. Koepl, J.W. Hurst, "Force Control for Planar Spring-Mass Running," IEEE International Conference on Intelligent Robots and Systems, September 2011.

D. Koepl, K. Kemper, and J.W. Hurst, "Force Control For Spring-Mass Running and Walking," IEEE Conference on Advanced Intelligent Mechatronics, July, 2010.

Kevin Kemper, Devin Koepl, and J.W. Hurst, "Optimal Passive Dynamics for Torque/Force Control," IEEE Conference on Robotics and Automation, May 2010.

J.W. Grizzle, J. Hurst, B. Morris, H.W. Park, K. Sreenath, "MABEL, A New Robotic Bipedal Walker and Runner," IEEE American Control Conference, June, 2009.

J.W. Hurst, B. Morris, J. Chestnutt, and A. Rizzi, "A Policy for Open-Loop Attenuation of Disturbance Effects Caused by Uncertain Ground Properties in Running," IEEE Conference on Robotics and Automation, April, 2007.

J.W. Hurst, J. Chestnutt, and A. Rizzi, "Design and Philosophy of the BiMASC, a Highly Dynamic Biped," IEEE Conference on Robotics and Automation, April, 2007.

J.W. Hurst, Daan Hobbelen, and A. Rizzi, "Series Elastic Actuation: Potential and Pitfalls," IEEE Workshop on Morphology, Control, and Passive Dynamics, International Conference on Intelligent Robots and Systems, 2005.

J.W. Hurst and A. Rizzi, "Physically Variable Compliance in Running," International Conference on Climbing and Walking Robots, Springer-Verlag, www.springeronline.com, September, 2004.

J.W. Hurst, J. Chestnutt, and A. Rizzi, "An Actuator with Physically Variable Stiffness for Highly Dynamic Legged Locomotion," IEEE Conference on Robotics and Automation, May, 2004. Detailed version available as technical report CMU-RI-TR-04-24.

Technical Reports J.W. Hurst, J. Chestnutt, and A. Rizzi, "An Actuator with Mechanically Adjustable Series Compliance," tech. report CMU-RI-TR-04-24, Robotics Institute, Carnegie Mellon University, April, 2004.

J.W. Hurst, J.W. Grizzle, H. Geyer, DARPA M3 program quarterly and annual reports, Q1-Q10, beginning April 2012 and ongoing

Patents U.S. Patent No. 8,914,151, "Apparatus and Method for Legged Locomotion Integrating Passive Dynamics With Active Force Control," Dec. 16, 2014

Patents Pending U.S. Patent Application No. 62/167,953; "Leg Configuration for Spring-Mass Legged Locomotion"
U.S. Provisional Application No. 62/141,323; "Apparatus and Method for Energy Regulation and Leg Control for Spring-Mass Walking Machine"

Invited Presentations **Robotics: Science and Systems**, Workshop on Challenges in Dynamic Legged Locomotion, July 2017

Amazon MARS (Machine-Learning, (Home) Automation, Robotics and Space Exploration) Conference, March 2017

Carnegie Mellon University, Robotics Institute Seminar, April 2016

Robotics Science and Systems, Workshop on Dynamic Locomotion, July 12-13, 2014

IEEE International Conference on Intelligent Robots and Systems (IROS), Workshop on Actuation Systems, Sept. 14-18, 2014

Georgia Institute of Technology, Robotics and Intelligent Machines Seminar, April 2013, <http://robotics.gatech.edu/news/seminars>

Live Demonstrations of ATRIAS monopod and biped:

DARPA Robotics Challenge, Pomona, California, May 2015; ATRIAS walked and ran.

Dynamic Walking Conference, Pensacola, Florida, May 2012

CLAWAR conference, Baltimore, MD, July 2012

Popular Mechanics Breakthrough Award, New York, NY, October, 2012.

IEEE Conference on Robotics and Automation:

Workshop on "Variable Stiffness Actuators moving the Robots of Tomorrow," May 2012

Workshop on "Achieving Robust, Compliant, Interactive Humanoid Robots via Active Force Control," May 2010

Workshop on "New Variable Impedance Actuators for the Next Generation of Robots," May 2010

DARPA PI meetings, M3 Program:

February 2011 Kickoff Meeting, October 2011, January 2012, August 2012, April 2014

Dynamic Walking Meetings:

Institute for Human and Machine Cognition, Pensacola, Florida, June 2012
University of Jena, Germany, June 2011
Massachusetts Institute of Technology, Boston, MA, 2010
Simon Frasier University, Vancouver, CA 2009
Mariehamn Island, Finland, June 2007
University of Michigan, June 2006
Carnegie Mellon University, June 2005
University of Michigan, June 2004

Current Research Funding Defense Advanced Research Projects Agency, “Natural Bipedal Walking and Running: Stealthy, Efficient, Robust,” total award: \$3,119,138, if options exercised; current incrementally funded amount: \$996,688, single PI award

National Science Foundation, “Leg Mechanics for Dynamic Locomotion,” total award 385,201\$, my share: 192,600\$

Teaching New curriculum development: ENGR 421/521, Applied Robotics, 4 units, S10: 5.1/4.5 (new course); S11: 38 students, no data; S12: 54 students, 5.1/4.9

New curriculum development: ME536, Actuator Dynamics, S11 (new course), 4 units, 7 students

ME451, Introduction to Instrumentation and Measurement Systems, 4 units, S09: 4.0/4.0 (updated course), F09: 4.2/4.2, F10: 4.1/4.3, S11: 76 students, 3.3/3.2 (new evaluation system), F12: 56 students, 3.6/3.7

ENGR212, Introduction to Dynamics, W09: 3.2/3.1, 3 units, 58 students

Advising

Graduate Students

- Andrew Abate, Ph.D. student (expected graduation: 2018)
- Patrick Clary, Ph.D. student (expected graduation: 2019)
- Kevin Greene, Ph.D. student (expected graduation: 2021)
- Taylor Apgar, Ph.D. student (expected graduation: 2021)
- Jesse Rond, M.S. student (expected graduation: 2019)
- Michael Hector, M.S. student (expected graduation: 2019)

Graduated

- Pavel Zaytsev, M.S., Imagination International
- Hamid Vejdani, Ph.D., Postdoctoral Associate at Brown University
- Christian Hubicki, Ph.D., Postdoctoral Associate at Georgia Tech
- Andrew Peekema, M.S., Honeybee Robotics
- Mikhail Jones, M.S., Agility Robotics
- Jesse Grimes, M.S., NASA JPL
- Kevin Kemper, M.S., Meka Robotics
- Devin Koepl, M.S., Hewlett-Packard

Postdoctoral Researchers

- Daniel Renjewski
- Siavash Rezazadeh
- Alex Sproewitz

Senior Design Projects

- Tendon design around a joint - MIME, 2016-17, Josh Dopp, Jacob Keeton, Tony Huynh

- ATRIAS foot prototype - MIME, 2013-14, Andy Abate, Ryan Skeelee, Allison Joyner
- Powered Robot gantry - MIME, 2013-14, Nathan Jones, Tyller Grey, Kelly Thomsen
- Powered Robot Gantry - EECS, 2013-14, Jake Yazici, Steven Burress, Joseph Green
- Brushless Motor Amplifier - EECS, 2012-13, Tyler Slone, Cody Hyman, Daniel Miller
- Spring Characterization Device - MIME, 2011-12, Nicholas Moses, Jonathan Jackson, Eric Hazlett
- Mars Rover chassis design - MIME, 2011-12, Jonathan Ayers, Ian Harsey, Aaron Wilson
- Mars Rover arm design - MIME, 2011-12, Andrew Peekema, Kasey Cousins, Richard Lee
- Design and construction of a robotic arm for Mars Rover - MIME, 2010-11, Jesse Grimes, Jon Doltar, Brandon Conroy
- Design and construction of a robot boom - MIME, 2009-10, Ben Jablonski, Jeff Inman, Andrew Mora
- Design and construction of a robotic arm for Mars Rover - MIME, 2009-10, Joe Hortnagl, Jon Nichols, Andrew Schroth
- Design and construction of a robotic arm for SWAT vehicle - MIME, 2009-10, Megan Colbath, Nick Cornilson, Max Broehl
- Design and construction of cable transmission testing device - MIME, 2009-10, Drew Arnold, Erik Hammagren, Thomas Wright
- Creation of stand-alone software simulation of bipedal running robot - EECS, 2009-10, Gavin Hills, Travis Moore, Jonathan Mark
- Design and construction of prototype robot leg - MIME, 2008-09, Joe Hertel, C.J. Veach, Devin Koepl, Fazil Tazunkan
- Design and construction of teleoperated reconnaissance vehicle for Salem, Oregon SWAT team - MIME, 2008-09, Chris Johnston, Scott Zenier, Rich Walloch

Undergraduate Honor's Theses

- Johnathan Van Why, Inertial Measurement, 2015
- Andy Abate, ATRIAS foot, 2014
- Allison Joyner, spring characterization testing, 2013
- Michael Summers, Cable Transmission Testing, 2010
- Devin Koepl, Force-Controller Actuator, 2009

Served on Ph.D. Committee

- Chris Holmes-Parker, Dynamics and Control, Oregon State University
- Delvin Pederson, Dynamics and Control, Oregon State University

Served on Masters Committee

- Stephen Sills, Mechanical Engineering, Oregon State University
- Ehsan Nasroullahi, Mechanical Engineering, Oregon State University
- Scott Carson, Industrial Engineering, Oregon State University
- Paul Bartlett, Lunar Rover prototype vehicle, Carnegie Mellon University.
- Nathan Abraham, Mini Bone-Attached Robotic System, Carnegie Mellon University.

University Service Co-founder of Robotics program at Oregon State University, continued leadership and development of program and facility.

Co-advisor to the Oregon State University Robotics Club, Sept. 2008-present; Club membership growth from 3-5 members up to over 100, with approximately \$20,000 per year spent on student robotics projects, and many students joining us for graduate school or going on to work for companies such as SpaceX or NASA.

Robotics faculty search committee, 2012-2017 (nearly every year, extensive involvement in selection, recruitment, and hiring of most robotics faculty members)

Mechanical Industrial and Manufacturing Engineering strategy committee, 2016-2017

Undergraduate Program Committee, 2011-2013

Outreach

Brought FIRST Tech Challenge to Oregon State as Tournament Director, Oregon State University Regional FIRST Tech Challenge, March 2010; competition has been run by the Robotics Club each year since.

Advised and encouraged the Robotics Club, via funding carrots, to demonstrate robots and generate a presence at regional competitions and schools, to recruit top engineering students to OSU.

Currently working with Robotics Club to host the FIRST Robotics competitions on campus.

Honors, Awards, and Publicity

A Google search for "Cassie Robot" returns 753,000 hits from news agencies all over the world. The Youtube page with the OSU-produced video currently sits at 471,580 views.

Awarded the Oregon State University College of Engineering Dean's Professorship, 2016.

Popular Mechanics "Breakthrough" Award, 2012:

<http://www.popularmechanics.com/technology/engineering/news/10-world-changing-innovators-for-slide-3>

Best Technical Paper, J.A. Grimes and J.W. Hurst, "The Design of ATRIAS 1.0: A Unique Monopod, Hopping Robot," International Conference on Climbing and Walking Robots (CLAWAR), July 2012.

Best Poster Presentation, "Optimization-Inspired Control Policies for Analytically and Computationally Intractable Systems," C. Hubicki and J.W. Hurst, Dynamic Walking, Principles and Concepts of Legged Locomotion, July 2011.

Control Systems Magazine cover story of MABEL, April 2011

Machine Design Magazine cover story on BiMASC, July 26, 2007

Engineering TV interviews on AMASC and BiMASC robots, episodes 37 and 38, <http://engineeringtv.com>

Integrative Graduate Education and Research Traineeship (IGERT) recipient, September 2005—September 2006.

Attended International School of Robot Science, September 2005, Tokyo, Japan. Awarded IEEE Fellowship for tuition.

National Science Foundation Graduate Fellowship recipient, August 2001—May 2003.

SAE International Walking Machine Decathlon 1st place, April 2000

Special Awards: Excellence in Autonomy, Best Technical Presentation.

Technology Transfer

Founded Agility Robotics; negotiated exclusive license agreement with Oregon State University for technology related to legged locomotion. Agility funded via three different sources of seed capital, and now manufacturing Cassie robots for academic customers. Goal: Cassie becomes the standard platform for leading research in walking and running. Longer term goal: automated logistics and package delivery.

Professional Activities

Associate Editor for IEEE Robotics and Automation Letters (IEEE RA-L) 2016-present

Area chair for hardware and control, Robotics: Science and Systems (RSS) 2017

Co-Organizer for Dynamic Walking meeting at the Florida Institute for Human and Machine Cognition, May 2012

Reviewer:

- IEEE Transactions on Robotics
- IEEE Journal of Robotics Research
- IEEE/ASME Transactions on Mechatronics
- IEEE Transactions on Systems, Man, and Cybernetics
- IEEE Transactions on Biomedical Engineering
- IEEE Sensors Journal
- The International Journal of Robotics Research
- Journal of Field Robotics
- Journal of Bioinspiration and Biomimetics
- International Journal of Humanoid Robotics
- ASME Journal of Dynamic Systems, Measurement and Control
- ASME Journal of Mechanical Design
- ASME Transactions on Mechatronics
- ASME International Design Engineering Technical Conferences and Computers and Information in Engineering Conference
- Public Library of Science (PLoS) ONE
- Robotics and Autonomous Systems Journal: Special Issue on Morphology, Control and Passive Dynamics, December 2005
- Robot Science and Systems (RSS)
- IEEE International Conference on Robotics and Automation (ICRA)
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
- ASME Dynamic Systems and Control Conference (DSCC)

Member, Institute of Electrical and Electronics Engineers (IEEE) Robotics and Automation Society

Assisted in organization of CMU Dynamic Walking meeting, 2005

- Chaired session on actuation for passive dynamics
- Co-organized program with Dr. Martijn Wisse for approximately 50 faculty and students from Cornell, Ohio State, Carnegie Mellon, MIT, Delft, and University of Michigan