

Devin J. Balkcom

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RESEARCH INTERESTS	Fundamental models of robot, animal, and human locomotion and manipulation. How should the machines we build do the things we do?	
EDUCATION	Carnegie Mellon University , Robotics Ph.D. 2004. Advisor Matthew Mason. Johns Hopkins University , B.A. 1998	
APPOINTMENTS	Associate Professor with tenure , Dartmouth College Faculty Co-director of Academic Computing , Dartmouth College Assistant Professor , Dartmouth College	2010 – present 2013 – 2016 2004 – 2010
AWARDS	Dartmouth McLane family fellowship, 2010-2011. John M. Manley Huntington Award for Newly Tenured Faculty, 2010.	
FUNDING	Neukom Comp-X grant: Computational design of deployable structures \$15,000. With Emily Whiting.	2016
	NSF EAGER: Computing compact roadmaps for motion planning \$149,999. Sole PI.	2014 – 2016
	NSF RI: Practical techniques for robotic manipulation of string and wire \$482,112. Sole PI.	2012 – 2016
	Neukom Comp-X grant: Efficient representations for robot motion planning \$20,000. With Amit Chakrabarti.	2012
	NSF Infrastructure grant: Digital Imaging Laboratory at Dartmouth \$480,000. With Hany Farid, Fabio Pellacini, Lorie Loeb.	2007 – 2010
	NSF CAREER award \$400,000.	2006 – 2011
	Department of Justice (ISTS): Mobility assessment for emergency response robots \$250,000. Co-PI with Laura Ray.	2006 – 2008
	Department of Justice Byrne Grant: automated assistance for disaster response \$181,360. Co-PI with Laura Ray.	2005 – 2007
	Department of Energy Computational Science Graduate Fellowship Full graduate student tuition and stipend; approximately \$220,000.	2000 – 2004
PH.D. STUDENTS	Yinan Zhang Yu-Han Lyu Weifu Wang Andrei Furtuna Paritosh Kavathekar Matthew Bell	September 2013 – present Ph.D. June 2016 Ph.D. June 2016 Ph.D. June 2011 Ph.D. June 2011 Ph.D. February 2010

GRADUATED M.S. STUDENTS	<p>Chang Jo Kim September 2013</p> <p>Zhong Li June 2013</p> <p>Wenyu Lu August 2011</p> <p>Govind Krishnan September 2009</p> <p>Wei Zhang (coadvised by Paul Thompson) June 2007</p> <p>Anne Loomis June 2006</p>
COURSES TAUGHT	<p>Tuck FWP: Fundamentals of Web Programming 2016, 2017</p> <p>With Hany Farid, designed, developed, and taught a new course for Tuck students interested in the intersection of technology and business. This hands-on-course covers web development in Javascript, HTML, CSS, with a particular emphasis on business applications.</p> <p>Tuck DSA: Data structures and analytics 2017</p> <p>With Hany Farid, designed, developed, and taught a new course for Tuck students interested in the intersection of technology and business. This hands-on-course follows the prior FWP course, and covers managing data in databases, representing data for computation in data structures, and data analysis using techniques from computer science and machine learning, with a particular emphasis on business applications.</p> <p>CS 1/5: Introduction to Programming and Computation 2005, 2006, 2008, 2011, 2012, 2015, 2016, 2017</p> <p>I designed and developed a new introductory undergraduate course, intended for both majors and non-majors. The course is programming intensive, and teaches fundamentals of Python programming, introductory object-oriented design, and topics from algorithms and data structures, including linked lists, trees, graphs, breadth-first search, and finite automata. CS 1 updates and replaces CS 5 in the curriculum.</p> <p>CS 50: Software Design and Implementation 2011, 2013</p> <p>This course is an intermediate course in software development and design. Students who have completed the first two introductory courses build a team project in this course, using C and Unix development tools. In the version of the course I developed and taught, students built a multi-player, networked, threaded implementation of a music-teaching game along the lines of the well-known commercial <i>Guitar Hero</i> game.</p> <p>CS 81: Principles of Robot Design and Programming 2006, 2008, 2009, 2011, 2012</p> <p>This advanced undergraduate course that I developed covers robot design and programming. There are two primary foci: a sequence of labs, and a rigorous introduction to mathematical techniques for analysis. The labs involve four mobile robots that the students program to autonomously explore a maze, and a real industrial robot arm that the student program for manipulation and assembly tasks. The mathematical analysis side covers kinematics, dynamics, the basics of modern control, and analysis of the stability of robot grasping.</p> <p>CS 76: Artificial Intelligence 2005, 2006, 2007, 2010, 2012, 2014, 2016</p> <p>This senior undergraduate course introduces basic applications and techniques in the field of Artificial Intelligence. Topics include knowledge representation, A* and iterative deepening search, scheduling, logic and theorem proving, competitive and cooperative games, optimization, probabilistic inference, with applications to robotics, natural language processing, and computer game development.</p> <p>CS 89/189: Robotics seminar 2005, 2006, 2009, 2010, 2016</p> <p>This undergraduate/graduate course presents basic techniques for modeling, simulation, planning, and control of robotic systems. Topics covered include configuration space, kinematics of</p>

open and closed chains, representations of rotations in 2D and 3D, homogeneous coordinates, constrained dynamics, the dynamics of friction and contact. Lab work includes programming an industrial robot arm.

CS 98: Senior design project **2012, 2013, 2014, 2015**

This course represents a culminating experience for graduating senior undergraduates. As part of a team, students design, develop, test, and release a piece of software.

CS 69: Design projects course **2013**

This course is a team-project course along the lines of CS 98, but targeted at first-, second-, and third-year students.

UNDERGRADUATE
RESEARCH
ADVISING

I have supervised more than 50 undergraduates on individual research projects, through the Dartmouth Women in Science Project, Presidential fellowship program, E.E. Just minority research program, and for senior theses.

PROFESSIONAL
COMMITTEES

IEEE Robotics and Automation Letters Associate Editor 2015 – present

NSF proposal review panels 2008, 2009, 2012, 2013, 2014, 2015

Workshop on the Algorithmic Foundations of Robotics (WAFR) program committee 2010, 2012, 2014, 2016

IEEE/RSJ International Conference on Intelligent Robots and Systems associate editor. 2005, 2006, 2007, 2011, 2012, 2013, 2014

IEEE International Conference on Robotics and Automation associate editor. 2011, 2012, 2013, 2014

Robotics: Science and Systems program committee. 2005, 2006, 2007, 2008, 2010, 2012

Reviewer for *The International Journal of Robotics Research*, the *IEEE Transactions on Robotics and Automation*, and other international journals. Judge for FIRST lego robotics competition, and for ASME National Student Mechanical Design Competition. Program committee member for *AAAI* and *Intelligent Autonomous Systems*. Area and publicity chair for *Robotics: Science and Systems* (2009).

FULL-LENGTH
PEER-REVIEWED
PAPERS

Copies of recent manuscripts are available from <http://www.cs.dartmouth.edu/~devin>

- [1] Yinan Zhang, Emily Whiting, and Devin Balkcom. "Assembling and disassembling planar structures with divisible and atomic components". In: *Algorithmic Foundations of Robotics (WAFR)*. 2016.
- [2] Weifu Wang and Devin Balkcom. "Re-configuring knots to simplify manipulation". In: *Algorithmic Foundations of Robotics (WAFR)*. 2016.
- [3] Yinan Zhang and Devin Balkcom. "Interlocking structure assembly with voxels". In: *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2016.
- [4] Weifu Wang and Devin Balkcom. "Grasping and folding knots". In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2016.
- [5] Weifu Wang and Devin Balkcom. "Towards tying knots precisely". In: *IEEE International Conference on Robotics and Automation (ICRA)*. Finalist for best manipulation paper. 2016.
- [6] Yu-Han Lyu and Devin Balkcom. "Optimal trajectories for planar rigid bodies with switching costs". In: *International Journal of Robotics Research* 35.5 (2016), pp. 454–475.
- [7] Yu-Han Lyu, Yining Chen, and Devin Balkcom. "k-survivability: diversity and survival of expendable robots". In: *IEEE International Conference on Robotics and Automation (ICRA)*. Also published as RAL journal article by the same name. 2016.

- [8] Yu-Han Lyu, Yining Chen, and Devin Balkcom. “k-survivability: diversity and survival of expendable robots”. In: *Robotics and Automation Letters* 1.2 (2016), pp. 1164–1171.
- [9] Weifu Wang and Devin Balkcom. “Towards arranging and tightening knots and unknots with fixtures”. In: *IEEE Transactions on Automation Science and Engineering* 12.4 (2015), pp. 1318–1331.
- [10] Devin Balkcom, Ajay Kannan, Yu-Han Lyu, Weifu Wang, and Yinan Zhang. “Metric cells: towards complete search for optimal trajectories”. In: *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2015.
- [11] Weifu Wang, Dmitry Berenson, and Devin Balkcom. “An online method for tight-tolerance insertion tasks for string and rope”. In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2015.
- [12] Weifu Wang, Devin Balkcom, and Amit Chakrabarti. “A fast online spanner for roadmap construction”. In: *International Journal of Robotics Research* 34.11 (2015), pp. 1418–1432.
- [13] Yu-Han Lyu, Andrei A. Furtuna, Weifu Wang, and Devin Balkcom. “The bench mover’s problem: minimum-time trajectories, with cost for switching between controls”. In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2014, pp. 106–112.
- [14] Matthew P. Bell, Weifu Wang, Jordan Kunzika, and Devin Balkcom. “Knot-tying with four-piece fixtures”. In: *International Journal of Robotics Research* 33.11 (2014), pp. 1481–1489.
- [15] Weifu Wang, Matthew Bell, and Devin Balkcom. “Towards arranging and tightening knots and unknots with fixtures”. In: *Algorithmic Foundations of Robotics (WAFR)*. 2014.
- [16] Yu-Han Lyu and Devin Balkcom. “Optimal trajectories for planar rigid bodies with switching costs”. In: *Algorithmic Foundations of Robotics (WAFR)*. 2014.
- [17] Weifu Wang, Devin Balkcom, and Amit Chakrabarti. “A fast streaming spanner algorithm for incrementally constructing sparse roadmaps”. In: *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2013, pp. 1257–1263.
- [18] Zhong Li, Devin Balkcom, and Aaron M. Dollar. “Rigid 2D space-filling folds of unbroken linear chains”. In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2013, pp. 551–557.
- [19] Andrei A. Furtuna, Weifu Wang, Yu-Han Lyu, and Devin Balkcom. “Structure and geometry of minimum-time trajectories for planar rigid bodies”. In: *Allerton Conference on Communication, Control, and Computing*. 2013, pp. 1584–1591.
- [20] Weifu Wang and Devin Balkcom. “Sampling extremal trajectories for planar rigid bodies”. In: *Algorithmic Foundations of Robotics (WAFR)*. 2012, pp. 331–347.
- [21] Weifu Wang and Devin Balkcom. “Analytical time-optimal trajectories for an omni-directional vehicle”. In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2012, pp. 4519–4524.
- [22] Andrei A. Furtuna, Wenyu Lu, Weifu Wang, and Devin Balkcom. “Minimum-time trajectories for kinematic mobile robots and other planar rigid bodies with finite control sets”. In: *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2011, pp. 4321–4328.
- [23] Paritosh A. Kavathekar, Bruce A. Craig, Alan M. Friedman, Chris Bailey-Kellogg, and Devin Balkcom. “Characterizing the space of interatomic distance distribution functions consistent with solution scattering data”. In: *Journal of Bioinformatics and Computational Biology* 8.2 (2010), pp. 315–335.
- [24] Matthew P. Bell and Devin Balkcom. “Grasping non-stretchable cloth polygons”. In: *International Journal of Robotics Research* 29.6 (2010), pp. 775–784.
- [25] Andrei A. Furtuna and Devin Balkcom. “Generalizing Dubins curves: minimum-time sequences of body-fixed rotations and translations in the plane”. In: *International Journal of Robotics Research* 29.6 (2010), pp. 703–726.
- [26] Hamid Reza Chitsaz, Steven M. LaValle, Devin Balkcom, and Matthew T. Mason. “Minimum wheel-rotation paths for differential-drive mobile robots”. In: *International Journal of Robotics Research* 28.1 (2009), pp. 66–80.
- [27] Andrei A. Furtuna, Devin Balkcom, Hamid Reza Chitsaz, and Paritosh A. Kavathekar. “Generalizing the Dubins and Reeds-Shepp cars: fastest paths for bounded-velocity mobile robots”. In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2008, pp. 2533–2539.

- [28] Matthew P. Bell and Devin Balkcom. "Knot tying with single piece fixtures". In: *IEEE International Conference on Robotics and Automation, (ICRA)*. 2008, pp. 379–384.
- [29] Devin Balkcom and Matthew T. Mason. "Robotic origami folding". In: *International Journal of Robotics Research* 27.5 (2008), pp. 613–627.
- [30] L. Ray, J. Joslin, J. Murphy, J. Barlow, and D. Brande. "Dynamic mobile robots for emergency surveillance and situational awareness". In: *IEEE International Workshop on Safety, Security, and Rescue Robotics*. 2006.
- [31] Devin Balkcom, Erik Demaine, Martin Demaine, John Ochsendorf, and Zhong You. "Folding paper shopping bags". In: *International Meeting of Origami Science, Math, and Education (OSME)*. 2006, pp. 315–334.
- [32] Devin Balkcom, Paritosh A. Kavathekar, and Matthew T. Mason. "The minimum-time trajectories for an omni-directional vehicle". In: *Algorithmic Foundation of Robotics (WAFR)*. 2006, pp. 343–358.
- [33] Anne Loomis and Devin Balkcom. "Computation reuse for rigid-body dynamics". In: *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2006, pp. 4181–4186.
- [34] Hamid Reza Chitsaz, Steven M. LaValle, Devin Balkcom, and Matthew T. Mason. "Minimum wheel-rotation Paths for differential-drive mobile robots". In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2006, pp. 1616–1623.
- [35] Devin Balkcom, Paritosh A. Kavathekar, and Matthew T. Mason. "Time-optimal trajectories for an omni-directional vehicle". In: *International Journal of Robotics Research* 25.10 (2006), pp. 985–999.
- [36] Devin Balkcom and Matthew T. Mason. "Introducing robotic origami folding". In: *IEEE International Conference on Robotics and Automation*. 2004, pp. 3245–3250.
- [37] Devin Balkcom and Matthew T. Mason. "Extremal trajectories for bounded velocity mobile robots". In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2002, pp. 1747–1752.
- [38] Devin Balkcom, E. J. Gottlieb, and Jeffrey C. Trinkle. "A sensorless insertion strategy for rigid planar parts". In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2002, pp. 882–887.
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- [42] Devin Balkcom and Matthew T. Mason. "Time optimal trajectories for bounded velocity differential drive robots". In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2000, pp. 2499–2504.
- [43] Devin Balkcom and Matthew T. Mason. "Extremal trajectories for bounded velocity differential drive robots". In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2000, pp. 2479–2484.