

Matthew A. Zucker

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RESEARCH INTERESTS:

Robotics, motion planning, machine learning, numerical optimization, navigation, manipulation, obstacle avoidance, dynamic simulation, computer vision, computer graphics.

EDUCATION:

2005–2010 **The Robotics Institute, Carnegie Mellon University**, Pittsburgh PA.
Ph.D. Robotics, conferred May 2011.

Dissertation: Learning and Optimization Methods for High Level Planning
Committee: James Kuffner (chair), Chris Atkeson, J. Andrew Bagnell,
Jean-Claude Latombe

1998–2002 **Vassar College**, Poughkeepsie NY.
B.A., Cognitive Science, with honors. Conferred May 2002.

RESEARCH EXPERIENCE:

2017–present **FlySorter SBIR**, *Swarthmore College / FlySorter LLC, Seattle WA*. NIH Phase I SBIR to develop hardware and software to automatically sort adult *Drosophila melanogaster* by phenotype.

2012–2014 **DARPA Robotics Challenge**, *Swarthmore College*. DARPA-funded competition to develop complex behaviors for humanoid robotics in a simulated disaster response scenario.

2007–2009 **Learning Locomotion**, *The Robotics Institute, Carnegie Mellon University*. DARPA-funded competition to investigate planning & control algorithms for legged robots on rough terrain; I led the CMU team.

2005–2007 **Vision for Safe Driving**, *The Robotics Institute, Carnegie Mellon University*. Developed search-based algorithms to predict and classify dangerous driving conditions.

1998–2000 **Standard Reference Data**, *National Institute for Standards and Technology*. Co-developed several online databases which have provided physics researchers with reference data for over 15 years.

TEACHING EXPERIENCE:

- 2016–present **Associate Professor**, *Department of Engineering, Swarthmore College*.
- 2010–2016 **Assistant Professor**. Courses include Mobile Robotics, Computer Vision, Numerical Methods, Humanoid Robotics, Fundamentals of Digital Systems, and Linear Physical Systems Analysis (labs).
- Summer 2006 **Teaching Assistant**, *Applications in Computer Graphics: Algorithmic Modeling and Animation, AITT Korea*. Korean government-sponsored initiative to familiarize university faculty with recent developments in the field.
- 2006, 2007 **Co-Coordinator**, *The Robotics Institute, Carnegie Mellon University*. Designed and taught a one-day LEGO robotics workshop to expose incoming Ph.D. students from diverse backgrounds to concepts including mechanism & software design, sensor integration, and debugging.
- Fall 2006 **Teaching Assistant**, *15-462: Computer Graphics I, Carnegie Mellon University*.
- Fall 2002 **Teaching Assistant**, *COGS 211: Perception & Action, Vassar College*.

INDUSTRY EXPERIENCE:

- 2014–present **Co-founder**, *FlySorter LLC, Seattle, WA*. Develop machine learning and computer vision software to classify images of *Drosophila melanogaster* for intelligent lab automation.
- Summer 2009 **Senior Software Engineer**, *Rep Invariant Systems, Cambridge MA*. US Navy Phase I SBIR. Implemented a software prototype for multi-client, collaborative mission development to extend existing aviator planning software.
- Summer 2008 **Software Consultant**, *SEEGRID Corp., Pittsburgh PA*. Developed algorithms and software for navigation and manipulation planning on high degree-of-freedom robotic platforms.
- 2000–2005 **Senior Software Engineer**, *Bluefin Robotics Corp., Cambridge MA*. MIT spin-off company designing and manufacturing autonomous underwater vehicles. Created operator tools for mission planning, diagnostics, and data analysis, as well as publish/subscribe inter-process communications software used onboard the vehicles.
- 2002–2003 **Software Consultant**, *Vassar College, Poughkeepsie NY*. Developed a secure, campus-wide online voting system for student body elections.

INTERACTIVE/PUBLIC SCHOLARSHIP:

- 2016–present **Needlessly Complex.** <https://mzucker.github.io> – Coding blog describing programming projects in computer graphics, computer vision, and artificial intelligence. As of October 2017, the site has received over 100k unique pageviews.
- 2014–present **Shadertoy.** <https://www.shadertoy.com/user/mattz> – Shadertoy.com is an online community of computer graphics developers and enthusiasts used for teaching and learning 3D computer graphics on the web. I use the site to research and disseminate novel math visualization techniques.

PROFESSIONAL ACTIVITIES:

Invited Speaker:

- *Trajectory optimization with dense constraints using multigrid CHOMP.* Autonomous Systems Labs, TU Darmstadt, July 2015; Max Planck Institute for Intelligent Systems, July 2015.
- *Robotics and learning: why humans are bad at telling robots what to do, and how math can help.* Swarthmore College Faculty Lecture, October 2014.
- *Gradient based trajectory optimization with CHOMP.* Healthcare Robotics Lab, Georgia Institute of Technology, April 2014.
- *Reinforcement Planning: RL for optimal planners.* GRITS Lab, Georgia Institute of Technology, February 2014.
- *A “big data” approach to exploring course enrollments at Swarthmore.* Concord Consortium, March 2014; Swarthmore College Faculty Lunch Lecture, September 2013.
- *Modes of knowledge acquisition: research, learning, and robots.* Swarthmore College Alumni Weekend Faculty Lecture, June 2013.
- *Robot motion planning via trajectory optimization with CHOMP.* Union College, Schenectady, NY, May 2013.
- *How much math should a robot know?* Birmingham Southern College, Birmingham AL, March 2012.
- *Learning for Planning: why humans are bad at telling robots what to do, and how math can help.* Drexel University, Philadelphia PA, November 2011.
- *Putting the learning back into Learning Locomotion.* Boston Dynamics, Inc., Waltham MA, February 2010.
- *Planning, Learning, and Optimization for Rough Terrain Locomotion.* Willow Garage, Menlo Park CA, 2009; University of Southern California, Los Angeles CA, 2009.

- *Embodied Intelligence: Robots (and cog sci grads) acting in the real world.* Vassar College, Poughkeepsie NY, 2008.
- *Learning motion models from recorded data.* DENSO Corporation, Nagoya Japan, 2006.
- *Navigation planning overview.* Toyota Research, Higashifuji Japan, 2005.

Journal Reviewer:

- Journal of Field Robotics
- International Journal of Robotics Research
- Autonomous Robots
- IEEE Transactions on Robotics
- IEEE Robotics and Automation Letters (RA-L)
- IEEE Transactions on Aerospace & Electronic Systems

Conference Reviewer/Coordinator:

- IEEE/RSJ Int'l Conference on Intelligent Robotics and Systems (IROS) – reviewer, associate editor
- IEEE-RAS Int'l Conference on Humanoid Robots – reviewer, associate editor
- International Conference on Machine Learning (ICML) – PC member
- Association for the Advancement of Artificial Intelligence (AAAI) Conference – PC member
- Robotics: Science and Systems Conference (RSS) – PC member
- IEEE Int'l Conference on Robotics and Automation (ICRA) – session co-chair, reviewer
- International Symposium on Robotics Research (ISRR) – reviewer
- IEEE Conference on Decision and Control – reviewer

Memberships:

- Member IEEE, Robotics and Automation Society.
- Member ASEE.
- Member Sigma Xi, *Inducted September 2011.*
- Member Phi Beta Kappa, *Inducted May 2002.*
- Member Psi Chi, *Inducted May 2002.*

Service at Swarthmore College:

- Co-chair, Sanctuary Campus Working Group, 2017
- Member, Self-Study Action Committee, 2016-2017
- Member, Fellowships and Prizes Committee, 2014-2015
- Member, Aydelotte Foundation Steering Committee, 2012-2015
- Member, Institutional Review Board, 2011-2013
- Treasurer, Sigma Xi chapter, 2012-2013

PUBLICATIONS (Swarthmore student co-authors are underlined):

Journal Articles:

- [1] M. Zucker, S. Joo, M.X. Grey, C. Rasmussen, E. Huang, M. Stilman, and A. Bobick. A general-purpose system for teleoperation of the DRC-HUBO humanoid robot. *Journal of Field Robotics*, 32(3):336–351, 2015.
- [2] M. Zucker, N. Ratliff, A. Dragan, M. Pivtoraiko, M. Klingensmith, C. Dellin, J.A. Bagnell, and S. Srinivasa. CHOMP: Covariant Hamiltonian optimization and motion planning. *International Journal of Robotics Research*, 32:1164–1193, August 2013.
- [3] M. Zucker, N. Ratliff, M. Stolle, J. Chestnutt, J.A. Bagnell, C. Atkeson, and J. Kuffner. Optimization and learning for rough terrain legged locomotion. *International Journal of Robotics Research*, 30(2):175–191, February 2011.

Submitted:

- [4] M. Zucker and Y. Higashi '18. A survey of cube-to-sphere projections and their applications. *Journal of Computer Graphics Techniques*. Submitted October 2017, under review.

Refereed International Conferences:

- [5] M.X. Grey, S. Joo, and M. Zucker. Planning heavy lifts for humanoid robots. In *Proc. IEEE-RAS Int'l Conf. on Humanoid Robotics*, 2014.
- [6] K. He '13, E. Martin '13, and M. Zucker. Multigrid CHOMP with local smoothing. In *Proc. IEEE-RAS Int'l Conf. on Humanoid Robotics*, 2013.
- [7] M. Zucker, Y. Jun, B. Killen, T. Kim, and P. Oh. Continuous trajectory optimization for autonomous humanoid door opening. In *Proc. IEEE Int'l Conf. on Technologies for Practical Robot Applications*, 2013.
- [8] M. Zucker and J.A. Bagnell. Reinforcement planning: RL for optimal planners. In *Proc. IEEE Int'l Conf. on Robotics and Automation*, May 2012.
- [9] M. Zucker, J.A. Bagnell, C. Atkeson, and J. Kuffner. An optimization approach to rough terrain locomotion. In *Proc. IEEE Int'l Conf. on Robotics and Automation*, 2010.
- [10] N. Ratliff, M. Zucker, J.A. Bagnell, and S. Srinivasa. CHOMP: Gradient optimization techniques for efficient motion planning. In *Proc. IEEE Int'l Conf. on Robotics and Automation*, 2009.
- [11] M. Zucker, J. Kuffner, and J.A. Bagnell. Adaptive workspace biasing for sampling based planners. In *Proc. IEEE Int'l Conf. on Robotics and Automation*, 2008.

- [12] N. Chan, J. Kuffner, and M. Zucker. Improved motion planning speed and safety using regions of inevitable collision. In *17th CISM-IFTOMM Symposium on Robot Design, Dynamics, and Control (RoManSy'08)*, 2008.
- [13] M. Zucker, J. Kuffner, and M. Branicky. Multipartite RRTs for rapid replanning in dynamic environments. In *Proc. IEEE Int'l Conf. on Robotics and Automation*, 2007.
- [14] M. Zucker. Fast seafloor topography extraction and visualization from sparse AUV altimeter data. In *Proc. Oceans '05 Europe Conference*, 2005.

Patents:

- [15] D.S. Zucker and M. Zucker. *Insect Singulating Device*. US Patent Application 2017/0071164 A1, September 2015.

Technical Reports:

- [16] M. Zucker. *Learning and Optimization Methods for High Level Planning*. PhD thesis, The Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, May 2010.
- [17] M. Zucker. Approximating state-space obstacles for non-holonomic motion planning. Technical Report CMU-RI-TR-06-27, Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, May 2006.
- [18] M. Zucker. *Evolution of cooperative controllers for multi-agent systems*. Undergraduate thesis, Cognitive Science Department, Vassar College, 2002.
- [19] M.J. Berger, J.S. Coursey, M.A. Zucker, and J. Chang. Stopping-power and range tables for electrons, protons, and helium ions. SRD 124, National Institute of Standards and Technology, Gaithersburg, MD, 2005.
- [20] Y.-K. Kim, K.K. Irikura, M.E. Rudd, M.A. Ali, P.M. Stone, J. Chang, J.S. Coursey, R.A. Dragoset, A.R. Kishore, K.J. Olsen, A.M. Sansonetti, G.G. Wiersma, D.S. Zucker, and M.A. Zucker. Electron-impact ionization cross section database. SRD 107, National Institute of Standards and Technology, Gaithersburg, MD, 2004.