

# Matt Zucker

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<https://mzucker.github.io/swarthmore/>

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## RESEARCH INTERESTS:

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

## 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.

## TEACHING:

2018–present **Engineering Department Chair**, *Swarthmore College*.

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, Computer-Aided Manufacturing and Procedural Design, Design and Sculpture in the Digital Age (co-taught) and Linear Physical Systems Analysis (labs).

## FUNDED RESEARCH:

2017–2019 **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.

**INDUSTRY:**

- Fall 2021     **Software Consultant**, *Positronix Corporation, Seattle WA*. Developed web-enabled teleoperation software for industrial robot arms and supported company software infrastructure.
- 2014–2020     **Co-founder**, *FlySorter LLC, Seattle, WA*. Developed 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 Fall 2020, the site has received over 335k 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:

- *Robotics education and research at a liberal arts college.* GRASP Students, Faculty, and Industry Seminar, University of Pennsylvania, April 2023.
- *A Foray into Computer-Assisted Quilting.* Swarthmore College Faculty Lunch Lecture, March 2023.
- *Engineering sabbatical: Highs, lows, & lessons learned.* Swarthmore College Faculty Lunch Lecture, October 2018.
- *Search, optimization, & learning for robot behavior generation.* Engineering Team, Harmonix Music Systems, Inc., Boston MA, August 2018.
- *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.

#### **Ph.D. Dissertation Committee Member:**

- MX Grey, *Motion Planning for Humanoid Platforms Using Randomized Possibility Graphs*, Ph.D. Robotics, Georgia Institute of Technology, 2016.

#### **Journal Reviewer:**

- Journal of Computer Graphics Techniques
- The Visual Computer
- Journal of Measurement and Control
- 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 Psi Chi, *Inducted May 2002.*

### **Service at Swarthmore College:**

- Board Observer for the Faculty, 2022-2024
- Member, Makerspace Committee, 2022-2023
- Member, Committee On Faculty Procedures (elected position), 2018-2020
- Secretary of the Faculty, 2018-2020
- Member, Center for Innovation and Leadership Advisory Board, 2018-2019
- 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 and Y. Higashi '18. Cube-to-sphere projections for procedural texturing and beyond. *Journal of Computer Graphics Techniques (JCGT)*, 7(2), June 2018.
- [2] 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.
- [3] 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.
- [4] 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.

### Other Peer-reviewed Publications:

- [5] A Foray Into Computer-Assisted Quilting. In Eve Torrence and Judy Holdener, editors, *Proceedings of Bridges 2023: Mathematics, Art, Music, Architecture, Culture*. Tesselations Publishing, 2023.
- [6] B. Willey and M. Zucker. Optimization-based planners. In M. Ang, O. Khatib, and B. Siciliano, editors, *Encyclopedia of Robotics*. Springer, 2021.
- [7] 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.
- [8] 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.
- [9] 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.
- [10] M. Zucker and J.A. Bagnell. Reinforcement planning: RL for optimal planners. In *Proc. IEEE Int'l Conf. on Robotics and Automation*, May 2012.
- [11] 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.
- [12] 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.
- [13] 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.
- [14] 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.
- [15] 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.
- [16] M. Zucker. Fast seafloor topography extraction and visualization from sparse AUV altimeter data. In *Proc. Oceans '05 Europe Conference*, 2005.

### Magazine Columns:

- [17] M. Zucker. The role of the liberal arts in undergraduate robotics education. *IEEE Robotics & Automation Magazine*, 26(3), 2019.

### **Artwork Featured In:**

- [18] Diana Davis. *Illustrating mathematics*. American Mathematical Society, 2020.
- [19] Robert Fathauer, editor. *Exhibition of Mathematical Art, 2023 Joint Mathematics Meetings Catalog*. Tesselations Publishing, 2023.

### **Technical Reports:**

- [20] M. Zucker. *Learning and Optimization Methods for High Level Planning*. PhD thesis, The Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, May 2010.
- [21] 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.
- [22] M. Zucker. *Evolution of cooperative controllers for multi-agent systems*. Undergraduate thesis, Cognitive Science Department, Vassar College, 2002.
- [23] 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.
- [24] 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.