

Michael Rubenstein – Curriculum Vitae

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Research Interests and Experience

- Multi-Robot Systems & Swarm Robotics
- Modular Self-Reconfigurable Robots
- Multi-Agent Systems
- Bio-Inspired Robots
- Self-Assembling & Self-Healing Systems
- Embedded Systems
- Education Robots

Education

- Ph.D. Computer Science**, *University of Southern California, D* **2009**
Thesis: *Self-Assembly and Self-Healing for Robotic Collectives*
Advisor: Wei-Min Shen
- M.S. Electrical Engineering**, *University of Southern California, Los Angeles, CA* **2005**
Area of Concentration: Robotics
- B.S. Electrical Engineering** *Purdue University, West Lafayette, IN* **2003**
Areas of Concentration: Control, Microprocessor Systems

Professional Appointments

- Assistant Professor** **2015-Present**
Department of Computer Science
Department of Mechanical Engineering
Northwestern University
- Assistant Professor** **2018-2021**
The Lisa Wissner-Slivka and Benjamin Slivka Professorship
Department of Computer Science
Department of Mechanical Engineering
Northwestern University
- Researcher** **2013-2015**
School of Engineering and Applied Sciences
Wyss Institute for Biologically Inspired Engineering
Harvard University
- Postdoctoral Fellow** **2010-2013**
School of Engineering and Applied Sciences
Wyss Institute for Biologically Inspired Engineering
Harvard University
- Research Assistant** **2004-2009**
Polymorphic Robotics Laboratory
University of Southern California, Information Sciences Institute
- Teaching Assistant**
University of Southern California
“CS 561: Foundations of Artificial Intelligence” **2006**
“CS 547: Sensing and Planning in Robotics” **2004**

Classes Developed and Taught

- CS 348: Introduction to Artificial Intelligence. (2017-present).
- CS/ME 410: Applied Mechatronics: Quadrotor Design and Control. (2016-present).
- CS/ME 409: Special Topics in Swarms and Multi-robot Systems. (2015-present).
- EECS 101 (Robotics Week) Fall 2017

Journal Publications

- Hanlin Wang, **Michael Rubenstein**. "Decentralized Localization in Homogeneous Swarms Considering Real-World Non-idealities." *IEEE Robotics and Automation Letters*, no. 4 (2021): 6765-6772.
- Taosha Fan, Hanlin Wang, **Michael Rubenstein**, Todd Murphey. "CPL-SLAM: Efficient and Certifiably Correct Planar Graph-Based SLAM Using the Complex Number Representation." *IEEE Transactions on Robotics* (2020).
- Hanlin Wang, **Michael Rubenstein**. "Walk, Stop, Count, and Swap: Decentralized Multi-Agent Path Finding with Theoretical Guarantees." *IEEE Robotics and Automation Letters* 5, no. 2 (2020): 1119-1126.
- Hanlin Wang, **Michael Rubenstein**. "Shape Formation in Homogeneous Swarms Using Local Task Swapping." *IEEE Transactions on Robotics* (2020).
- **Michael Rubenstein**, Alejandro Cornejo, Radhika Nagpal. "Programmable Self-Assembly in a Thousand Robot Swarm." *Science*, Vol. 345, no 6198, 15 Aug 2014.
- **Michael Rubenstein**, Christian Ahler, Nick Hoff, Adrian Cabrera, Radhika Nagpal. "Kilobot: A Low Cost Robot with Scalable Operations Designed for Collective Behaviors." *Robotics and Autonomous Systems*, 62, no. 7:966-975., 2014.
- **Michael Rubenstein**, Ying Sai, Cheng-Ming Choung, Wei-Min Shen. "Regenerative Patterning in Swarm Robots: Mutual Benefits of Research in Robotics and Stem Cell Biology." *The International Journal of Developmental Biology*, 53:869–881, 2009.
- Wei-Min Shen, Maks Krivokon, Harris Chiu, Jacob Everist, **Michael Rubenstein**, Jagadesh Venkatesh. "Multimode Locomotion for Reconfigurable Robots." *Autonomous Robots*, 20(2):165–177, 2006.

Peer Reviewed Conference Publications

- Hanlin Wang, **Michael Rubenstein**. "Generating Goal Configurations for Scalable Shape Formation in Robotic Swarms." *International Symposium on Distributed Autonomous Robotic Systems 2021*.
- Petras Swissler, **Michael Rubenstein**. "ReactiveBuild: Environment-Adaptive Self-Assembly of Amorphous Structures." *International Symposium on Distributed Autonomous Robotic Systems 2021. (winner of Best Student Paper Award)*
- Petras Swissler, **Michael Rubenstein**. "FireAnt3D: a 3D self-climbing robot towards non-latticed robotic self-assembly" *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2020)*.
- Florian Schiffrers, Thomas Bochynek, Andre Aichert, Tobias Wurfl, **Michael Rubenstein**, Oliver Cossairt. "Disassemblable Fieldwork CT Scanner Using a 3D-printed Calibration Phantom", *6th International Conference on Image Formation in X-Ray Computed Tomography*, 2020.

- Ji Chen, Hanlin Wang, **Michael Rubenstein**, Hadas Kress-Gazit. “Automatic Control Synthesis for Swarm Robots from Formation and Location-based High-level Specifications.” 2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2020).
- Yihan Zhang, Lyon Zhang, Hanlin Wang, Fabian Bustamante, **Michael Rubenstein**. “SwarmTalk – Towards Benchmark Software Suites for Swarm Robotics Platforms”. Proc. Of the 19th International Conference on Autonomous Agents and Multi agent Systems (AAMAS 2020).
- Florian Schiffers, Thomas Bochynek, Andre Aichert, Tobias Wurfl, **Michael Rubenstein**, Oliver Cossairt. “Disassemblable Fieldwork CT Scanner Using a 3D-printed Calibration Phantom”. CT Meeting 2020.
- Hanlin Wang, **Michael Rubenstein**. “A Fast, Accurate, and Scalable Probabilistic Sample-Based Approach for Counting Swarm Size”, 2020 IEEE International Conference on Robotics and Automation (ICRA 20).
- Taosha Fan, Hanlin Wang, **Michael Rubenstein**, Todd Murphey, “Efficient and Guaranteed Planar Pose Graph Optimization Using the Complex Number Representation”, 2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 19) (**Best Student Paper Award**)
- **Michael Rubenstein**, Zachary Manchester. “Bio-Inspired Position Control of Satellite Constellations.” Int. Symp. on Distributed Autonomous Robotic Systems (DARS 18).
- Andrew SaLoutos, **Michael Rubenstein**. “SpinBot: An Autonomous, Externally Actuated Robot for Swarm Applications.” Int. Symp. on Distributed Autonomous Robotic Systems (DARS 18). (**Nominated best student paper**)
- Petras Swissler, **Michael Rubenstein**. “FireAnt: A Modular Robot with Full-Body Continuous Docks.” *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2018.
- German Espinosa, Michael Rubenstein. “Using Hardware Specialization and Hierarchy to Simplify Robotic Swarms.” *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2018.
- Marc Gyongyosi, Alexander Daley, Blake Resnick, **Michael Rubenstein**. “Low Cost Sensing and Communication System for Rotor Craft.” Low Cost Sensing and Communication System for Rotor Craft IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2017)
- Melinda Malley, **Michael Rubenstein**, Radhika Nagpal. “Flippy: A Soft, Autonomous Climber with Simple Sensing and Control.” IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2017).
- Gauci, Melvin, Monica E. Ortiz, **Michael Rubenstein**, and Radhika Nagpal. "Error Cascades in Collective Behavior: A Case Study of the Gradient Algorithm on 1000 Physical Agents." In *Proceedings of the 16th Conference on Autonomous Agents and MultiAgent Systems*, pp. 1404-1412. International Foundation for Autonomous Agents and Multiagent Systems, 2017.
- Melvin Gauci, Radhika Nagpal, **Michael Rubenstein**. “Programmable Self-Disassembly for Shape Formation in Large-Scale Robotic Collectives.” International Symposium on Distributed Autonomous Robotic Systems (DARS), 2016.
- Hanlin Wang, **Michael Rubenstein**. “Autonomous Mobile Robot with Independent Control and Externally Driven Actuation.” *IEEE Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2016.
- Martin Nisser, Samuel Felton, Michael Tolley, **Michael Rubenstein**, Robert Wood. “Feedback-Controlled Self-Folding of Autonomous Robot Collectives.” *IEEE Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2016.

- **Michael Rubenstein**, Bo Cimino, Radhika Nagpal, Justin Werfel. "AERobot: An Affordable One-Robot-Per-Student System for Early Robotics Education." *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2015.
- Lucian Cucu, **Michael Rubenstein**, Radhika Nagpal. "Towards Self-Assembled Structures with Mobile Climbing Robots." *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2015.
- **Michael Rubenstein**, Adrian Cabrera, Justin Werfel, Golnaz Habibi, James McLurkin, Radhika Nagpal. "Collective Transport of Complex Objects by Simple Robots: Theory and Experiments." *Intl. Conf on Autonomous Agents and Multi-Agent Systems (AAMAS)*, 2013.
- Aaron Becker, Golnaz Habibi, Justin Werfel, **Michael Rubenstein**, James McLurkin. "Massive Uniform Manipulation: Controlling Large Populations of Simple Robots with a Common Input Signal." *IEEE Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2013.
- **Michael Rubenstein**, Christian Ahler, Radhika Nagpal. "Kilobot: A Low Cost Scalable Robot System for Collective Behaviors." *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2012.
- **Michael Rubenstein**, Wei-Min Shen. "Automatic Scalable Size Selection for the Shape of a Distributed Robotic Collective." *IEEE Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2010.
- **Michael Rubenstein**, Radhika Nagpal. "Kilobot: A Robotic Module for Demonstrating Collective Behaviors." Modular Robotics Workshop, *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2010.
- **Michael Rubenstein**, Wei-Min Shen. "Scalable Self-Assembly and Self-Repair in a Collective of Robots." *IEEE Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2009.
- Harris Chi Ho Chiu, Bo Ryu, Hua Zhu, Pedro Szekely, Rajiv Maheswaran, Craig Rogers, Aram Galstyan, Behnam Salemi, **Mike Rubenstein**, Wei-Min Shen. "TENTACLES: Self-Configuring Robotic Radio Networks in Unknown Environments." *IEEE Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2009.
- Wei-Min Shen, Robert Kovac, **Michael Rubenstein**. "SINGO: A Single-End-Operative and Genderless Connector for Self-Reconfiguration, Self-Assembly and Self-Healing." *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2009.
- **Michael Rubenstein**, Wei-Min Shen. "A Scalable and Distributed Approach for Self-Assembly and Self-Healing of a Differentiated Shape." *IEEE Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2008.
- **Michael Rubenstein**, Wei-Min Shen. "A Scalable and Distributed Model for Self-Organization and Self-Healing." *Intl. Conf on Autonomous Agents and Multi-Agent Systems (AAMAS)*, 2008.
- Wei-Min Shen, Harris Chiu, **Michael Rubenstein**, Behnam Salemi. "Rolling and Climbing by the Multifunctional Superbot Reconfigurable Robotic System." *Space Technology and Applications Intl. Forum (STAIF)*, 2008.
- Harris Chiu, **Michael Rubenstein**, Wei-Min Shen. "Deformable Wheel - A Self-Recovering Modular Rolling Track." *Intl. Symposium on Distributed Robotic Systems (DARS)*, 2008.
- Harris C. H. Chiu, **Michael Rubenstein**, Wei-Min Shen. "Multifunctional Superbot with Rolling Track Configuration." Workshop on Self-Reconfigurable Robots, *IEEE Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2007.
- Wei-Min Shen, Maks Krivokon, Harris Chiu, Jacob Everist, **Michael Rubenstein**, Jagadesh Venkatesh. "Multimode Locomotion Via Superbot Robots." *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2006.

- **Michael Rubenstein**, Maks Krivokon, Wei-Min Shen. "Robotic Enzyme-Based Autonomous Self-Replication." *IEEE Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2004.
- **Michael Rubenstein**, Kenneth Payne, Peter Will, Wei-Min Shen. "Docking Among Independent and Autonomous CONRO Self-Reconfigurable Robots." *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2004.

Robot Demonstrations, Talks, and Outreach

- Computation in Science Seminar, University of Chicago, October 2021.
- Semiautonomous Seminar, UC Berkeley, December 2020.
- Invited presentation, IEEE Chicago, July 2020.
- "Northwest Indiana IEEE student night", Valparaiso University, November 2016.
- "Challenges in Modeling and Control of Small-Scale Robots workshop", invited speaker, Robotics Science and Systems, June 2016.
- "RoMa 2016: Robot Makers workshop", invited speaker, Robotics Science and Systems, June 2016.
- "Greater Chicago Area Systems Research Workshop", invited speaker, April 2016.
- "MTO "Unplugged" Offsite DARPA meeting, invited speaker, January 2016.
- "Wait, What?" DARPA forum on future technologies, invited demo, September 2015.
- "Computations in Science" seminar invited talk, University of Chicago, April 2015.
- "Design and Control of a Thousand-Robot Collective"
 - Invited Talk, micro-nano robotic swarms workshop, IROS 2014.
- "BugBots: Programming Mini-Robots"
 - I2 STEM summer camp course for 5th-8th graders, 2014.
- "Robobee Exhibit", Boston Museum of Science, Technical advisor, 2013.
- "Kilobot: An Open Source Research Robot"
 - Invited demo, Open Hardware Summit, Massachusetts Institute of Technology, September 2013.
- "Kilobot: A 1024 Robot Platform for Implementing Collective Behaviors"
 - Invited talk, Northwestern Institute on Complex Systems seminar, Northwestern University, December 2012.
- "Creating a More Adaptable Robot With Multi-Robot Systems"
 - Invited talk, BBN Cambridge, May 2012.
- "Planetary Contingency Challenge"
 - 1st place winner, IEEE International Conference on Robotics and Automation (ICRA), 2012.
- "Harvard Bio-Inspired Robotics"
 - Boston Museum of Science, (National Robotics Week), April 2012.
- "Kilobot: Demonstrating a 100 Robot Swarm"
 - Demonstration Session, Int'l. Conference on Intelligent Robots and Systems, September 2011.
- "Bots That Mimic Bugs"
 - Cambridge Science Festival, May 2011.
- "Harvard Bio-Inspired Robotics"
 - Boston Museum of Science, (National Robotics Week), April 2010.
- "Superbot Reconfigurable Robot Demonstration"

- Multi-Robot Teaming Challenge and Robotics Exhibition, International Joint Conference on Artificial Intelligence (IJCAI), June 2009.
- “Planetary Contingency Challenge”
 - Competition using Superbot, 1st place winner, IEEE International Conference on Robotics and Automation (ICRA), 2008.
- "Self-Reconfigurable Robotics"
 - Wired “NextFest”, Los Angeles Convention Center, September 2007.

Select Media Coverage

- BBC News: "Thousand-strong robot swarm throws shapes, slowly", 15 Aug 2014.
- Wall Street Journal: "Harvard Scientists Devise Robot Swarm That Can Work Together", 15 Aug 2014.
- NPR: "All Things Considered" Do Not Fear This Giant Robot Swarm", Aired 14 Aug 2014.
- National Science Foundation news: "The 1,000-robot swarm", 14 Aug 2014.
- National Geographic: "A Swarm of a Thousand Cooperative, Self-Organizing Robots", 14 Aug 2014.
- Nature News: "Researchers create 1,000-robot swarm", 14 Aug 2014.
- Scientific American: "1,000-Robot Swarm Created by Researchers", 14 Aug 2014.
- Slashdot: "A Thousand Kilobots Self-Assemble Into Complex Shapes", 14 Aug 2014.
- IEEE Spectrum: "A Thousand Kilobots Self-Assemble Into Complex Shapes", 14 Aug 2014.
- Wired: "Scientists Program Largest Swarm of Robots Ever", 14 Aug 2014.
- ACM Communications Magazine: "Rise of the Swarm", March 2013.
- Scientific America Magazine, March 2013.
- Slashdot: "African Robotics Network Challenge Spurs Rash of \$10 Robots", September 2012.
- Wired: "These \$10 Robots Will Change Robotics Education", September 2012.
- Inside Nova: "Adventures in Swarm Robotics", September 2012.
- Slashdot: "Harvard Licenses Technology For Tiny Swarming Robot", November 2011.
- RobotsPodCast: "Robots: Demonstrations at IROS", October 2011.
- IEEE Spectrum: "Kilobots Are Cheap Enough to Swarm in the Thousands", June 2011.
- Slashdot: "Kilobots - Cheap Swarm Robots Out of Harvard", June 2011.
- New Scientist: "Born to be Viral: Robot Swarm Forages for Food", June 2011.
- Make Magazine: "Harvard's \$14 Swarm-bot Design", June 2011.
- Engaget: "Harvard's Kilobot Project Does Swarm Robots On The Cheap", June 2011.
- Popular Science: "Introducing Kilobot, a Swarm Robot Cheap Enough to Actually Swarm", June 2011.
- BBC: "Visions of the Future - The Intelligence Revolution", 2008.
- Discovery Channel: "Beyond Tomorrow", November 2005.

Professional Activities

Committee and Conference Organization

- Area Chair: “Robotics Science and Systems” (RSS) 2022.
- Area Chair: “Robotics Science and Systems” (RSS) 2021.
- Associate editor IEEE Transactions on Robotics (2020-present)
- Editorial board: Swarm Intelligence Journal (2016-present)
- Committee Chair: Robotics and Automation Society educational project with IEEE Spectrum, 2018-present.
- Program Committee: “Robotics Science and Systems” (RSS) 2018.
- Program Committee: “International Conference on Swarm Intelligence” (ANTS) 2018.

- Co-organizer: “Swarms: From Biology to Robotics and Back”, ICRA 2018.
- Program Committee: “Robotics Science and Systems” (RSS) 2017.
- Program Committee: “International Symposium on Distributed Autonomous Robotic Systems” 2016.
- Awards Chair: “International Symposium on Distributed Autonomous Robotic Systems” 2016.
- Co-organizer: “Workshop on Modular and Swarm Systems”, IROS 2014.
- Program Committee: “ANTS- International Conference on Swarm Intelligence”, 2014.
- Program Committee: “International Workshop on Robotic Sensor Networks”, 2014.

Reviewer

- Nature.
- Science.
- NSF review panel, 2017,2019,2021
- IEEE International Conference on Robotics and Automation (ICRA)
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
- Journal of Autonomous Agents and Multi-Agent Systems
- IEEE Transactions on Robotics (T-RO)
- Robotica Journal
- Robotics and Autonomous Systems Journal
- Robotics Science and Systems (RSS)
- IEEE Transactions on Automation Science and Engineering
- Distributed Autonomous Robotic Systems (DARS)