Michael Rubenstein – Curriculum Vitae

McCormick School of Engineering
Northwestern University
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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, Los Angeles, CA* **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 **2018-Present**
The Lisa Wissner-Slivka and Benjamin Slivka Professorship
Department of Electrical Engineering and Computer Science
Department of Mechanical Engineering
Northwestern University

Assistant Professor **2015-Present**
Department of Electrical Engineering and 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**

Grants, Awards, and Notable Achievements

- Sloan Fellow (2017-2018).
- Provisional patent "METHOD AND SYSTEM FOR JOINING ROBOTIC COMPONENTS"
- Provisional patent "SENSING AND COMMUNICATION SYSTEM FOR ROTORCRAFT"
- Report published in the journal Science, August 15, 2014.
- Searle Fellows Program, Searle Center for Advanced Learning and Teaching, Northwestern University. Teaching fellow (2016-2017)
- Funded grant: "Engineering Self-Organizing Systems: Investigating Top-Down Synthesis of Resilient Collectives Using a 1000 Robot Experimental Platform", DARPA (BAA-FP-027) 2015.
- Funded grant: "Collective Robotics for Life Scientists", NSF (DUE-1353236) 2014-15.
- 1st place winner, AFRON "Ultra Affordable Education Robot" Design Challenge, 2012, 2014.
- Kilobot robot commercially licensed to K-TEAM Corporation, starting September 2011.

Classes Developed and Taught

- Introduction to Artificial Intelligence. (Spring 2017,Spring 2018).
- EECS 101 (Robotics Week) Fall 2017
- Applied Mechatronics: Quadrotor Design and Control. (Spring 2016, Spring 2017, Winter 2018).
- Special Topics in Swarms and Multi-robot Systems. (Fall 2015, Fall 2016, Fall 2017, Fall 2018).

Journal Publications

- **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

- **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

- "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 5^{th}-8^{th} 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

Conference Organization

- 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

- Editor: Swarm Intelligence Journal
- Nature.
- Science.
- NSF review panel, 2017
- 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)

Mentoring and Advising

- Andrew Saloutos, M.S. Student (ME), Northwestern University 2017-2018.
- Hanlin Wang, PhD. Student (EECS), Northwestern University 2017-present.
- Petras Swissler, PhD. Student (ME), Northwestern University 2016-present.
- German Espinosa, PhD. Student (EECS), Northwestern University 2016-present.
- Hanlin Wang, M.S. student (Mechanical Engineering), Northwestern University 2015-2016.
- Luca Brusatin, visiting M.S. student (EPFL), Thesis: "Dispersion Algorithms on the Kilobot Swarm".
- Lucian Cucu, visiting M.S. student (EPFL), Thesis: "Towards Self-Assembled Structures with Mobile Climbing Robots".
- Adrian Cabrera, visiting M.S. student (EPFL), Thesis: "Collective Transport in Large Swarms of Simple Robots".
- Bo Cimino, summer REU student, "Programming Environment for the AERobot Education Robot".
- Afrida Chowdhury, summer REU student, "A Volumetric Capacitive Sensor for Modeling Ant Self-Assemblages".