

# Nils Napp

Assistant Professor

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## Academic Training

**Post-Doctoral Fellow**, Wyss Institute for Bio-Inspired Engineering, *Harvard University* 2011–current.

**PhD Electrical Engineering**, *University of Washington* 2006–2011.

**MS Electrical Engineering (Control Systems)**, *University of Washington* 2003–2006.

**BS Engineering, BS Mathematics**, *Harvey Mudd College* 1999–2003, with high distinction.

## Research Experience

*Spring 13–current*  
*Harvard Univ.* Compiling machine learning algorithms to molecular systems. The goal of this project is to bring probabilistic reasoning tools that have been extremely successful at solving problems in robotics, e.g. machine vision, mapping, and sensor fusion, to the realm of molecular machines which face huge amounts of noise and component uncertainty [6].

*Summer 13*  
*Harvard Univ.* Developing valve and strategy for underactuated control of soft robots. Using this strategy a single pressure source can pressurize multiple chambers to different levels when they interconnected with via passive valves [5].

*Spring 11–current*  
*Harvard Univ.* Developing hardware, models, and control strategies for amorphous robotic construction. The goal of this project is to enable robotic construction in unstructured, cluttered environments by using amorphous materials. Designing construction models and algorithms that take advantage of mechanically compliant construction materials can greatly simplify sensing and planning requirements [1,4,7,8].

*Spring 12*  
*Harvard Univ.* Developing a 3D terrain acquisition system for biological fieldwork. The goal of this project was to capitalize on advances in computer vision to understand, and ultimately model, construction behavior in social insects [9].

*Fall 08–Spring 11*  
*Univ. Washington* Developing software and control strategies for the Factory Floor Testbed (designed in the ModLab, University of Pennsylvania). My contribution to this project was to design a concurrent programming language for specifying and modeling local reactive behavior. I used compositional features of this language to design robust routing and load balancing programs [2,10,11].

*Spring 04–Spring 08*  
*Univ. Washington* Design and construction of two robotic test-beds to investigate engineered self-assembly. The Programmable Parts Testbed [14, 15, 16] is a multi-robot system designed to investigate programming stochastic self-assembly. I worked on experimentally validating optimal assembly rules for low copy number stochastic self-assembly. The Robotic Chemistry Testbed [2, 12] is a multi-robot system designed to develop and test feedback controllers for stochastic self-assembling systems.

# Publications

## Journal Publications

- [1] **N. Napp** and R. Nagpal. “Distributed Amorphous Ramp Construction in Unstructured Environments”. *Robotica*, Volume 32(2), pp 279–290. PDF
- [2] **N. Napp** and E. Klavins. “A Compositional Framework for Programming Stochastically Interacting Robots”. *International Journal of Robotics Research*, Volume 30(6), pp 713–729, 2011. PDF
- [3] **N. Napp**, S. Burden, and E. Klavins. “Setpoint Regulation for Stochastically Interacting Robots”. *Autonomous Robots*, Volume 30(1), pp 57–71, 2011. PDF

## Peer Reviewed Conference Publications

- [4] **N. Napp** and R. Nagpal. “Robotic Construction of Arbitrary Shapes with Amorphous Materials”. *International Conference on Robotics and Automation (ICRA)*, (accepted) 2014. PDF
- [5] **N. Napp**, B. Araki, M. T. Tolley, R. Nagpal, and R. J. Wood. “Simple Passive Valves for Addressable Pneumatic Actuation”. *International Conference on Robotics and Automation (ICRA)*, (accepted) 2014.
- [6] **N. Napp** and R. P. Adams. “Message Passing Inference with Chemical Reactions”. *Advances in Neural Information Processing Systems (NIPS)*, Lake Tahoe, NV, USA, 2013. **Selected for oral presentation.** PDF
- [7] **N. Napp** and R. Nagpal. “Distributed Amorphous Ramp Construction in Unstructured Environments”. *International Symposium on Distributed Autonomous Robotic Systems (DARS)*, Baltimore, MD, USA, 2012. **Runner-up prize for Best Conference Paper** award. PDF
- [8] **N. Napp**, J. M. Wu, O. R. Rappoli, and R. Nagpal. “Materials and Mechanisms for Amorphous Robotic Construction”. *International Conference on Intelligent Robots and Systems (IROS)*, Vilamoura, Portugal, 2012. PDF
- [9] K. Petersen, **N. Napp**, J. Chin-Lee, J. Werfel and R. Nagpal. “3D Tracking of Building Processes in Macrotermes”. *Visual Observation and Analysis of Animal and Insect Behavior, Workshop at International Conference on Pattern Recognition (ICPR)*, Tsukuba Science City, Japan, 2012. PDF
- [10] **N. Napp** and E. Klavins. “Load Balancing for Multi-Robot Construction”. *International Conference on Robotics and Automation (ICRA)*, Shanghai, China, 2011. PDF
- [11] **N. Napp** and E. Klavins. “Robust by Composition: Programs for Multi-Robot Systems”. *International Conference on Robotics and Automation (ICRA)*, Anchorage, AK, USA, May 2010. PDF
- [12] **N. Napp**, S. Burden, and E. Klavins. “Setpoint Regulation for Stochastically Interacting Robots”. *Robotics: Science and Systems (RSS)*, Seattle, WA, USA, 2009. **Nominated for Best Student Paper** award. PDF
- [13] **N. Napp**, D. Thorsley, and E. Klavins. “Hidden Markov Models for Non-Well-Mixed Reaction Networks”. *American Control Conference (ACC)*, St. Louis, MO, USA, 2009. PDF

## Publications (continued)

- [14] S. Burden, **N. Napp**, and E. Klavins. “The statistical dynamics of programmed robotic self-assembly”. *International Conference on Robotics and Automation* (ICRA), pages 1469-1476, 2006. PDF
- [15] E. Klavins, S. Burden, and **N. Napp**. “Optimal rules for programmed stochastic self-assembly”. *Robotics: Science and Systems* (RSS), Philadelphia, PA, 2006. PDF
- [16] J. Bishop, S. Burden, E. Klavins, R. Kreisberg, W. Malone, **N. Napp**, and T. Nguyen. “Self-organizing programmable parts”. *International Conference on Intelligent Robots and Systems* (IROS) Edmonton, AB, Canada, 2005. PDF

### Thesis

- [17] *Control of Stochastically Interacting Particles: With Applications to Robotics*. PhD thesis University of Washington, Department of Electrical Engineering 2011. Advisor: Eric Klavins.

## Talks and Presentations

N. Napp, “Bio-Inspired Design of Robust Local Algorithms”, Invited talk: Rutgers University 2014

N. Napp, “Message Passing Inference with Chemical Reaction Networks”, Invited talk: Molecular Programming Retreat 2013. Contributed Talk: NIPS Lake Tahoe 2013

N. Napp, “Bio-Inspired Control Strategies for Distributed Robotic Systems”, Invited talks: Yale University 2013, University of California San Diego 2013, Boston University 2013, University of Hawaii Manoa 2013.

N. Napp, “Amorphous Robotic Construction”, Invited talks: Drexel University 2013, Massachusetts Institute of Technology (Rus Group) 2013, Worcester Polytechnic Institute 2012.

N. Napp, “Building with Stochastic Depositions”, Invited talk: California Institute of Technology (Murray Group) 2011.

N. Napp, “Guarded Command Programming with Rates”, Invited talks: California Institute of Technology 2010, Cornell University 2010, Harvard University 2010, Johns Hopkins University 2010, University of Pennsylvania 2010.

N. Napp and E. Klavins. “Stochastic, Concurrent Programs for Reconfigurable Robot Systems: Guarded Command Programs With Rates”. *International Conference on Robotics and Automation* (ICRA09), Kobe, Japan, May 2009. Workshop: Formal Methods in Robotics and Automation.

N. Napp and E. Klavins. “An extended state-space Markov chain model for self-organizing systems in non-well-mixed environments”. *In 4th Annual Conference on the Foundations of Nanoscience* (FNANO07), Snowbird, UT, April 2007. Contributed Talk + Abstract.

S. Burden, N. Napp, and E. Klavins. “Tuning reaction networks for self-assembly”. *In 3rd Annual Conference on the Foundations of Nanoscience* (FNANO06), Snowbird, UT, April 2006. Poster + Abstract.

## **Talks and Presentations (continued)**

Exhibit at NSF Headquarters “Robots: An Exhibition of U.S. Automatons from the Leading Edge of Research”. Washington DC September 2005.

## **Paper Awards and Media Coverage**

Programming Smart Molecules. Dec 2013. CACM, Slashdot, Harvard SEAS  
Oral presentation at Neural Information Processing Systems (NIPS) [6]. (<% 2 of submissions)  
Robots: Construction with Amorphous Materials. Robot Podcast, Sept 2013  
Runner up for Best Paper award at Distributed Autonomous Robotic Systems (DARS) [7].  
Bug-Inspired Robots Designed to Do Our Dirty Work. Discover Magazine, May 2013  
Robot Builds Ramp by Randomly Flinging 3,600 Toothpicks, IEEE Automaton, Oct 2012  
Robotic Chemistry Autonomous Robots Blog, Oct 2010  
Nominated for Best Student Paper at Robotic Science and Systems (RSS) 2010. [12]  
Cover of IEEE Control Systems Magazine Vol. 27(4) 2007

## **Teaching and Outreach**

### *Teaching and Advising*

ES100 Engineering Design Capstone, Harvard. 2013-2014.  
Supervised REU students, Harvard, 2013, 2012, 2011.  
EE426/7 Engineering Capstone (Control Theory), University of Washington 2010, 2008.  
EE499 Special projects, University of Washington.

### *Outreach*

Cambridge Science Festival, Robot Zoo, 2013.  
SET in the City for High School Girls, 2013.  
Presentations for local high-school classes, 2013, 2012, 2011.  
Museum of Science, Robot Block Party, 2012, 2011.  
Engineering Open House, University of Washington 2006, 2005.

## **Professional Services**

### *Reviewer for Journal Submissions*

Autonomous Robots  
Distributed Computing  
International Journal of Robotics Research  
Journal of Micromechanics and Microengineering  
Robotica  
Robotics and Automation Magazine  
Transactions on Automatic Control  
Transactions on Mechatronics  
Transactions on Systems, Man, and Cybernetics–Part B: Cybernetics

### *Reviewer for Conference Submissions*

American Control Conference 2012, 2009, 2008  
Conference on Decision and Control, 2008  
Distributed Autonomous Robotic Systems 2012  
Hybrid Systems: Computation and Control 2009

## Professional Services (continued)

International Conference on Intelligent Robots and Systems 2012, 2011, 2010, 2009, 2008  
International Conference on Robotics and Automation 2013, 2012, 2010, 2008

### *Other*

Charied session. “Formations in Multi-Robot Systems”. DARS 2012.

Charied session. “Mechanism Design I”. IROS 2012.

Organized Special Session. “Stochastic Multi-Robot and Modular Robot Systems”. ICRA 2010.

## References

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