

## Research Overview

My research explores algorithmic methods for designing and controlling autonomous systems, guaranteeing correctness with respect to formal specifications. I focus on safety-critical applications involving cyber-physical systems performing complex tasks in adversarial environments, interacting with a variety of agents. My work combines technical and creative perspectives from formal methods for software verification, hybrid systems, robotics, control and game theory.

## Professional Experience

**United Technologies Research Center** August 2015-present  
*Position:* Senior Scientist

**California Institute of Technology** August 2013-July 2015  
*Position:* Postdoctoral Scholar  
*Affiliation:* The TerraSwarm Research Center  
*Advisors:* Richard Murray and Sanjit Seshia

## Education

**Cornell University**, Ithaca, NY 2007 - 2013  
PhD, Computer Science  
Advisor: Hadas Kress-Gazit  
Graduate Minor: Economics

**Wellesley College**, Wellesley, MA 2003 - 2007  
B.A. magna cum laude  
Majors: Computer Science and Mathematics

**University of Edinburgh**, Scotland, UK Spring 2006  
Visiting Student at the School of Informatics

**Mahindra United World College of India**, Pune, India 2001 - 2003  
International Baccalaureate Diploma

## Awards and Honors

**NSF Cyber-Physical Systems Early-Career Investigator's Research Competition Winner** (2015)

*Socially responsible smart-cities: Smarter delivery of community service through population sensing and urban technology.* Ongoing collaboration with Yasser Shoukry (UCLA) & Min Kyung Lee (CMU)

Invited to attend the **Second Heidelberg Laureate Forum** (2014)

The Heidelberg Laureate Forum brings together winners of the Fields Medal, Abel Prize, Turing Award, and Rolf Nevanlinna Prize with young researchers for a mix of formal lectures and informal interactions. Selected as one of 200 from an application pool of approximately 2000. Includes a travel award to attend the Forum.

**Outstanding TA Award**, Cornell Department of Computer Science (2008-09)

Certificate of achievement for outstanding contributions as a Teaching Assistant

**John McMullen Dean's Fellowship**, Cornell University College of Engineering (2007-08)

Merit-based fellowship awarded to first-year PhD students

**Phi Beta Kappa** (awarded March 2007)

**Sigma Xi** (awarded May 2007)

**Wellesley College Computer Science Department Honors**

Honors Thesis: "Learning Primitive Predicates for Probabilistic Planning"

Advisors: Ellen Hildreth (Wellesley), Leslie Kaelbling (MIT)  
**Jerome A. Schiff Honors Thesis Fellowship (2006-2007)**  
Competitive Award for Senior Honors Thesis

- Journal Articles**
- Vasumathi Raman, Hadas Kress-Gazit. (2013). “Explaining Impossible High-Level Robot Behaviors”. *IEEE Transactions on Robotics*, 29(1): 94-104, 2013.
- Constantine Lignos, Vasumathi Raman, Cameron Finucane, Mitch Marcus, Hadas Kress-Gazit. (2015). “Provably Correct Reactive Control from Natural Language”. *Autonomous Robots*, 38(1): 89-105, 2015.
- Vasumathi Raman, Nir Piterman, Cameron Finucane, Hadas Kress-Gazit. “Timing Semantics for Abstraction and Execution of Synthesized High-Level Robot Control”. *IEEE Transactions on Robotics*, 31(3): 591-604, 2015.
- Vasumathi Raman, Hadas Kress-Gazit. “Unsynthesizable Cores – Minimal Explanations for Unsynthesizable High-Level Robot Behaviors”. In submission.
- Vasumathi Raman, Alexandre Donzé, Mehdi Maasoumy, Richard M. Murray, Alberto Sangiovanni-Vincentelli, Sanjit A. Seshia. “Receding Horizon Control Synthesis with Signal Temporal Logic Specifications”. In preparation.
- Conference Publications**
- Samira Farahani, Vasumathi Raman, Richard M. Murray. (2015). “Robust Model Predictive Control for Signal Temporal Logic Synthesis”. In *Proc. of the 5th IFAC Conference on Analysis and Design of Hybrid Systems (ADHS 15)*. Atlanta, GA, USA. October 2015.
- Vasumathi Raman, Mattias Fält, Tichakorn Wongpiromsarn, Richard M. Murray. (2015). “On-line Horizon Selection in Receding Horizon Temporal Logic Planning”. In *Proc. of the 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2015)*. Hamburg, Germany. September 2015.
- Jonathan DeCastro, Javier Alonso-Mora, Vasumathi Raman, Daniela Rus, Hadas Kress-Gazit. (2015). “Collision-Free Reactive Mission and Motion Planning for Multi-Robot Systems”. In *Proc. of the 2015 International Symposium of Robotics Research (ISRR 2015)*. Sestri Levante, Italy. September 2015.
- Jonathan DeCastro, Vasumathi Raman, Hadas Kress-Gazit. (2015). “Dynamics-Driven Adaptive Abstraction for Reactive High-Level Mission and Motion Planning”. In *Proc. of the 2015 IEEE International Conference on Robotics and Automation (ICRA 2015)*. Seattle, WA, USA. May 2015.
- Mattias Fält, Vasumathi Raman, Richard M. Murray. (2015). “Variable Elimination for Scalable Receding Horizon Temporal Logic”. In *Proc. of the 2015 American Control Conference (ACC 2015)*. Chicago, IL, USA. July 2015.
- Vasumathi Raman, Alexandre Donzé, Dorsa Sadigh, Richard M. Murray, Sanjit A. Seshia. (2015). “Reactive Synthesis from Signal Temporal Logic Specifications”. In *Proc. of the 2015 International Conference on Hybrid Systems: Computation and Control (HSCC 2015)*. Seattle, WA, USA. April 2015.
- Vasumathi Raman, Alexandre Donzé, Mehdi Maasoumy, Richard M. Murray, Alberto Sangiovanni-Vincentelli, Sanjit A. Seshia. (2014). “Model Predictive Control with Signal Temporal Logic Specifications”. In *Proc. of the 2014 IEEE Annual Conference on Decision and Control (CDC 2014)*. Los Angeles, CA, USA. December 2014.
- Vasumathi Raman. (2014). “Reactive Switching Protocols for Multi-Robot High-Level Tasks”. In *Proc. of the 2014 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2014)*. Chicago, USA. September 2014.
- Vasumathi Raman, Hadas Kress-Gazit. Synthesis for multi-robot controllers with interleaved motion. In *Proc. of the 2014 IEEE International Conference on Robotics and Automation (ICRA 2014)*. Hong Kong, China. June 2014.
- Vasumathi Raman, Hadas Kress-Gazit. (2013). “Towards Minimal Explanations of Unsynthesizability for High-Level Robot Behaviors”. In *Proc. of the 2013 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2013)*. Tokyo, Japan. October 2013.
- Vasumathi Raman, Constantine Lignos, Cameron Finucane, Kenton Lee, Mitch Marcus, Hadas Kress-Gazit. (2013). “Sorry Dave, I’m Afraid I Can’t Do That: Explaining Unachievable

- Robot Tasks Using Natural Language”. In Proc. of the 2013 Robotics: Science and Systems Conference (RSS 2013). Berlin, Germany. June 2013.
- Vasumathi Raman, Nir Piterman, Hadas Kress-Gazit. (2013). “Provably Correct Continuous Control for High-Level Robot Behaviors with Actions of Arbitrary Execution Durations”. In Proc. of the 2013 IEEE International Conference on Robotics and Automation (ICRA 2013). Karlsruhe, Germany. May 2013.
- Vasumathi Raman, Cameron Finucane, Hadas Kress-Gazit. (2012). “Temporal Logic Robot Mission Planning for Slow and Fast Actions”. In Proc. of the 2012 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2012). Vilamoura, Algarve, Portugal. October 2012.
- Vasumathi Raman, Bingxin Xu, Hadas Kress-Gazit. (2012). “Avoiding Forgetfulness: Structured English Specifications for High-Level Robot Control with Implicit Memory”. In Proc. of the 2012 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2012). Vilamoura, Algarve, Portugal. October 2012.
- Vasumathi Raman, Hadas Kress-Gazit. (2012). “Automated Feedback for Unachievable High-Level Robot Behaviors”. In Proc. of the 2012 IEEE International Conference on Robotics and Automation (ICRA 2012). St. Paul, Minnesota, USA. May 2012.
- Vasumathi Raman, Hadas Kress-Gazit. (2011). “Analyzing Unsynthesizable Specifications for High-Level Robot Behavior Using LTLMoP”. In Proc. of the 23rd International Conference on Computer Aided Verification (CAV 2011). Snowbird, Utah, USA. July 2011.
- Joseph Halpern, Rafael Pass, Vasumathi Raman. (2009). “An Epistemic Characterization of Zero Knowledge”. In Proc. of the 12th Conference on Theoretical Aspects of Rationality and Knowledge (TARK XII). Palo Alto, California, USA. July 2009.

#### Workshop Publications (peer-reviewed)

- Rüdiger Ehlers, Vasumathi Raman. (2014). “Low-Effort Specification Debugging and Analysis”. 3rd Workshop on Synthesis (SYNT 2014). Vienna, Austria. July 2014.
- Vasumathi Raman, Alexandre Donzé, Mehdi Maasoumy. (2014). “Model-Predictive Control from Signal Temporal Logic Specifications: A Case Study”. 4th Workshop on Design, Modeling and Evaluation of Cyber Physical Systems (CyPhy’14). Berlin, Germany. April 2014.

#### Theses

- Vasumathi Raman (2013). “Explaining Unsynthesizability of High-Level Robot Behaviors”. (2013). PhD Thesis, Cornell University, Ithaca, NY, August 2013.
- Vasumathi Raman. (2007). “Learning Primitive Predicates for Probabilistic Planning”. Honors Thesis, Wellesley College. Wellesley, MA, May 2007.

#### Key Projects

- The First Challenge on Formal Methods for Robotics** 2014-Present  
Collaborators: Scott C. Livingston (Caltech)  
*Aim:* Compared to other areas within robotics research, demonstrations of formal methods have been surprisingly small-scale. This challenge, to be held at the IEEE International Conference on Robotics and Automation (ICRA) in May 2016, seeks to motivate advancement of the state of the art toward practical realization. Details and code are available on the challenge website at <http://www.fmrchallenge.org/>.
- Provably Correct Control for Robot Teams** 2013-Present  
Collaborators: Hadas Kress-Gazit (Cornell), Nora Ayanian (USC)  
*Aim:* Synthesis of centralized and decentralized controllers that guarantee safe execution and goal fulfillment for complex tasks involving teams of robots.
- Model Predictive Control Synthesis from Timed Logics** 2013-Present  
Collaborators: Richard M. Murray (Caltech), Sanjit Seshia (UC, Berkeley)  
*Aim:* A framework for posing model-predictive control tasks as synthesis from signal temporal logic specifications. Motivated by smart micro-grid or building-level power systems with controllable loads and generators, and desired timed properties such as the maximum period of power loss during failures or outages.

	<b>Timing Semantics for High-Level Robot Control</b>	2011-2013
	Advisor: Hadas Kress-Gazit (Cornell University)	
	<i>Aim:</i> Automatically constructing robot hybrid controllers that guarantee safe execution and goal fulfillment for tasks involving low-level controllers of varying execution times.	
	<b>Explaining Unsynthesizable Specifications For High-Level Robot Behaviors</b>	2010-2013
	Advisor: Hadas Kress-Gazit (Cornell University)	
	<i>Aim:</i> Finding suitable explanations of unsynthesizable LTL specifications for robot control by exploiting the structure of the control tasks and combining existing and novel techniques from formal methods.	
	<b>Computational Models of Games With Time Pressure</b>	2009-2010
	Advisors: Joseph Halpern, Rafael Pass, Bart Selman (Cornell University)	
	<i>Aim:</i> Formalizing a computational model to capture game-theoretic properties of time pressure in games such as speed chess and deadline-based negotiations.	
	<b>Epistemic Characterization of Cryptographic Concepts In Modal Logic</b>	2008-2009
	Advisors: Joseph Halpern, Rafael Pass (Cornell University)	
	<i>Aim:</i> Providing an extended modal logic syntax and semantics for describing a range of cryptographic properties.	
	<b>Learning Primitive Predicates for Probabilistic Planning</b>	2006-2007
	Advisors: Leslie Kaelbling (MIT), Ellen Hildreth (Wellesley College)	
	<i>Aim:</i> Creating a bootstrapping framework for probabilistic planning using supervised learning of task-specific primitive predicates.	
Teaching and Advising Experience	<b>Lecturer at the NSF ExCAPE Summer School on Software Synthesis</b>	June 2015
	MIT, Cambridge, MA	
	Planned and instructed a two-part tutorial on <i>synthesis for robotics</i> , including a hands-on exercise with using state-of-the-art synthesis tools like LTLMoP and BluSTL.	
	<b>Instructor for ME/CS 132: Advanced Robotics</b>	Spring 2015
	California Institute of Technology, Pasadena, CA	
	Planned and instructed an advanced undergraduate course on robot motion planning. This is a project-based course including a laboratory component.	
	<b>Undergraduate and Graduate Project Advising</b>	2013-Present
	Caltech and UC Berkeley	
	Planned and guided the following research projects:	
	<ul style="list-style-type: none"> <li>Abishek Akella, Aldrich Ong, John Song (<i>MPC-on-chip for temporal logic specifications</i>)</li> <li>Dexter Scobee, Omid Bagherieh (<i>MPC primitives for compositional synthesis from temporal logic specifications</i>)</li> <li>Mattias Fält (<i>efficient receding horizon control from temporal logic specifications</i>) This project has resulted in two conference publications to date.</li> <li>Joon Sik (David) Kim (<i>environment assumptions for temporal logic control</i>)</li> <li>Jean-Maurice Leonetti (<i>constructing discrete abstractions for robot motion planning</i>)</li> <li>Benjamin Wu (<i>formal verification of building access control systems</i>)</li> </ul>	

- CURIE Academy Teaching Assistant** July 2012  
 Cornell University, Ithaca, NY  
 Supervised lab-work and provided teaching support for a week long robotics summer school for high school girls.
- Undergraduate Independent Study Advisor** (Advisee: Brian Finn) Fall 2011  
 Cornell University Autonomous Systems Lab, Ithaca, NY  
 Planned and supervised a for-credit undergraduate research project on interfacing SAT solvers with the JTLV temporal logic synthesis tool, with the goal of identifying unsatisfiable cores of robot specifications.
- Teaching Assistant for Decision Theory** Fall 2010  
 Cornell University Department of Computer Science, Ithaca, NY  
 Graded coursework, held office hours, and provided course feedback to the instructor. Course Instructor: Joe Halpern.
- Head TA, Object-Oriented Programming and Data Structures** Spring 2009  
 Cornell University Department of Computer Science, Ithaca, NY  
 Delegated and monitored grading, consulting and teaching responsibilities to a staff of 30 TAs. Graded coursework, taught a weekly section, and guest-lectured on special topics. Received outstanding TA award. Course Instructor: Graeme Bailey.
- Grader for Computer Science Advanced Standing Exam** Fall 2009, 2010, 2012  
 Cornell University Department of Computer Science, Ithaca, NY  
 The Department of Computer Science uses this exam to determine whether incoming freshmen receive credit for CS1110 (Introduction to Computing). Graded placement exams, assessed student knowledge, and decided whether students would be awarded credit (in some cases conditional on completing a 4-week object-oriented programming course).
- Computer Science and Mathematics Tutor** 2004-2007  
 Wellesley College, Wellesley, MA  
 Held regular group and individual tutoring sessions for a range of CS and math courses.

## Professional Service

### Conference Activities

- Organizer**, TerraSwarm Security and Privacy Workshop, 2014
- Organizer**, ICRA Workshop on Formal Methods for Robotics, 2015
- Organizer**, RSS Workshop on Abstraction and Synthesis of Correct-by-Construction Robotics Software, 2015
- Program Committee**, Robotics: Science and Systems Conference, 2015
- Program Committee**, IFAC Conference on Analysis and Design of Hybrid Systems, 2015
- Senior PC**, International Joint Conference on Artificial Intelligence, 2016
- Session Chair**, ICRA 2014

### Reviewing

- IEEE Transactions on Robotics (T-RO 2013-15)
- IEEE Transactions on Automation Science and Engineering (T-ASE 2015)
- International Journal of Robotics Research (IJRR 2014)
- Logical Methods in Computer Science (LMCS 2015)
- IEEE Journal of Oceanic Engineering (JOE 2015)
- IEEE International Conference on Robotics and Automation (ICRA 2012-16)
- American Control Conference (ACC 2013-15)
- IEEE Conference on Decision and Control (CDC 2013-15)
- International Conference on Cyber-Physical Systems (ICCPS 2016)
- International Conference on Hybrid Systems: Computation and Control (HSCC 2016)
- North-East Student Colloquium on Artificial Intelligence (NESCAI 2008, 2010)

**Judge**, Cornell Mathematical Contest in Modeling (2011, 2012)

## Other Service

### Mentoring

Caltech Women Mentoring Women Program (September 2013-present)  
Cornell SWE Mentoring Program (August 2011-May 2013)  
Cornell CSGO-ACSU Mentoring Program (August 2010-May 2011)

### Teaching Volunteer at MacCormick Secure Center

June-August 2011

MacCormick is a maximum-security correctional facility for young men aged 16-21 who have committed violent crimes. Taught a communication skills summer course; topics covered included thought organization and job interview preparation. Ran weekly sessions with small class sizes and one-on-one instruction, working primarily with inmates close to being released.

### Computer Science Graduate Organization (CSGO)

2009 - 2011

Founding Member and Social Chair, coordinating department-wide social events.

### Expanding Your Horizons

2007 - 2013

EYH is a one-day conference for 7th-9th grade girls that comprises hands-on workshops and demonstrations by Cornell students and faculty. The conference aims to stimulate the girls' interest in math and science, provide them with female scientist role models, and introduce them to career opportunities in math and science.

**Fundraising Chair (2012-13):** Raised over \$25,000 each year to fund EYH at Cornell.

**Lansing Correctional Center Outreach Chair (2011-12):** Organized and supervised an EYH mini-conference at the Lansing Correctional Center for Girls in Lansing, NY. Responsibilities included soliciting student-run workshops, negotiating logistics with correctional center staff, and keeping workshop leaders aware of and compliant with the center's policies.

**Diversity Chair (2009-10):** Increased participation from rural and inner city schools by 20 or more each year. **Workshop Coordinator (2008-2012):** Organized several workshops introducing the girls to various topics in CS, including introductory graph theory and programming using Scratch.