Teaching Statement

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My teaching goal mirrors my inter-disciplinary approach towards research: I aim to ensure that students cultivate a holistic view of life-critical and safety-critical system development by drawing stronger connections between real-time and embedded systems, control systems, formal methods and hands-on platform development. I design courses that have a significant experimental component, where students work in teams to develop sizable distributed embedded systems that integrate concepts across electrical and computer engineering, computer science, bioengineering and mechanical engineering. These include building test-beds for energy-efficient building heating/cooling systems, electric vehicle powertrain systems, Heart-on-a-Chip medical devices, biofeedback control systems and leader-follower quadrotor aircraft systems[1].

By emphasizing *learning by doing*, I aim to develop students' confidence in deconstructing a design problem, iterating over several inefficient designs, presenting intermediate results, incorporating creativity in engineering solutions and finally integrating the hardware, software, controls and mechanical components into a working system. In following this *design-driven approach*, every student is continually making decisions on how to deconstruct the problem, how to partition functionality to different sub-systems, how to keep things simple, how to define clean and generic interfaces at hardware/software boundaries and finally how to demonstrate the core ideas within the operational system in an effective way. This emphasis on developing hands-on critical thinking skills forms the bedrock of my teaching approach.

In the rest of this statement, I will summarize the Embedded Systems courses I have developed at Penn and discuss plans for a broader curriculum on Model-based Design of Systems. I will describe my efforts in developing cross-school collaborations within Penn, student and faculty based teaching events, and establishing Penn as a recognized force across global engineering communities.

A. Embedded Systems at Penn

In 2008, there were no courses in the Electrical & Systems Engineering and Computer & Information Science departments with a significant *hands-on system building philosophy* that spanned the boundaries of hardware design and software development. In the past four years, in collaboration with faculty from both departments, I helped develop the Embedded Systems program at Penn. This involved the new Computer Engineering (CE) undergraduate program and the new Embedded Systems Masters program (EMBS). Both programs are tremendously popular, with the number of applicants increasing 3-fold each year. In the past year, there were over 280 applicants for the popular EMBS program.

Graduates, who were under my supervision during and after the course, have gone on to join Stanford (Kevin Conley'12 and Jeff Kiske'13), Georgia Tech (Matt Hale'12), Duke (Ashleigh Thomas'13), UCLA (Paul Martin'11), CMU (Utsav Drolia'11) and Penn (Paul Gurniak'12) for their doctoral degrees. While a significant number of graduates prior to 2008 went to non-engineering and financial firms, students I have mentored have joined SpaceX, Tesla Motors, NASA (Langley), GoogleX Labs, BOSCH Research, Intel, Nvidia, Qualcomm, etc.

For projects developed in the courses I taught, students have won national and international recognition in the form of 1st Prize in the World Embedded Systems Competition, Seoul, Korea in 2010 *and* 2012; The 2012 Intel-Cornell Cup Embedded Systems Award, 1st Prize in the Intel Innovators $50K Award, The 2012 SEAS Best Senior Design Award, Google Zeitgeist Award'12, Honeywell Industrial Wireless Innovation Award'11, and over **15** other awards. Undergraduate and Masters students' class projects have been published in over a dozen conference venues and over half-dozen maintained open-source projects. See Appendix for the full list. Due to these efforts, Penn is now considered a veritable force in the area of Embedded Systems.

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[1] For a really exciting compilation of ESE350 project videos, see http://tinyurl.com/ese350videos

B. Embedded Systems Course Development

At Penn, I have developed three new courses in the area of Embedded Systems: I teach the undergraduate ESE350 Introduction to Embedded Systems & Microcontroller Laboratory, a 1.5 credit course which is a core requirement for the Computer Engineering major. I teach the graduate ESE519 Real-Time and Embedded Systems course, which is a core requirement for the EMBS program. Both courses follow a similar format of 5 labs in the first 11 weeks that builds basic hardware/software concepts and skills, and is followed by a 4-week final project. All student teams pick projects of their choice and have a good degree of freedom on their approach and tools as long as the systems: (a) Have a significant embedded systems component (no PC or laptop allowed in the final demonstration); (b) Solve a problem with a real need; and (c) Have a strong closed-loop component with sensing, controls and actuation.

(a) ESE350 Introduction to Embedded Systems *(Spring 2010-Present)*

This course introduces the use of microcontrollers, sensors and actuators in building real systems that interact with the physical world. With an approach focused heavily on learning by doing, the labs are designed to be interactive, fun, yet challenging. The students build:

- Morse code decoder - to learn I/O, polling and timers
- Telephone signaling system - to learn interrupts and analog circuits
- An electro-mechanical elevator system – to learn analog-to-digital conversion and motors
- Sensor-Actuator Interfaces - to learn signal processing for sensing
- Whack-a-Mole game – to learn about wireless communication and interaction

The lab exercises begin with well-defined instructions where the students initially program the hardware in C at the bare metal, i.e. no software APIs (using 16-bit Freescale microcontrollers). The labs progressively get more open-ended in the approach students can use. In addition, the students progress to use microcontroller-programming libraries (with 32-bit ARM microcontrollers) and eventually work with embedded operating system (using 32-bit ARM multiprocessors). This ensures the basics of hardware-software interfaces are learned and allow the students to gradually abstract away the low-level details and incorporate more *system-wide thinking* in their projects.

The final 4 weeks feature an open-ended project where students are asked to build creatively on the foundations they have learned by designing and developing an embedded system of their own. Examples of such systems include tele-operated leader-follower quadrotors, body sensor games based on hacked Nintendo/Sega console games, electro-mechanical chess, connect-4 and basketball shootout machines, spherical robots, etc. Projects from ESE350 have won over *16 national and international awards*. See Appendix for list.

ESE350 prepares students well for their senior design projects and has resulted in Senior Design Awards in 2009 (ESE), 2011 (ESE & CIS), and 2012 (ESE, CIS & SEAS). Readings, lectures, and discussions serve to support the main concepts of the laboratory exercises while pre-lab quizzes, laboratory reports, and exams ensure that the concepts are well understood. To reflect on these approaches, I routinely participate in Senior Design activities and have given a talk to the 2013 seniors on '*Senior Design. Done Right.*'

(b) ESE519 Real-Time and Embedded Systems *(Fall 2010-Present)*

This core graduate course covers the concepts, theory, and tools necessary to understand, design, and build real-time and concurrent embedded systems. The course is spread across five major modules starting with an introduction to networked embedded systems, real-time scheduling theory, concurrent programming and distributed systems theory, life-critical systems and case studies in embedded system failures. Five labs introduce programming with a real-time operating system (RTOS); networked operation across distributed embedded systems; development of routing protocols; and design of safety-critical systems. Each group is given a set of wireless embedded nodes, 32-bit embedded multi-processor boards (700MHz and 1GHz) and a variety of sensors and actuators. Final projects have included:

- Energy-efficient building automation systems, which integrate sensing, distributed controls and building automation algorithms for heating and cooling in HVAC systems.

- Automotive embedded systems that integrate control systems for traction, stability, anti-lock braking, and adaptive cruise control with a hardware-in-loop test-bed.
- Computer vision-based robot-soccer with multi-robot consensus protocols for offense and defense strategies
- Implementation of new wireless protocols (ISA100.11a) for industrial control and automation

Student projects from ESE519 have resulted in over 12 international conference publications and demos in venues such as ACM/IEEE Cyber-Physical Systems Week, ACM Embedded Systems Week, ACM Building Systems Symposium and the IEEE Real-Time Systems Symposium (RTSS).

(c) Graduate Seminar on Wireless Sensor/Actuator Networks *(Offered intermittently)*

This course is targeted at understanding and obtaining hands-on experience with state of the art wireless sensor/actuator networks (WSAN) with applications ranging from environmental monitoring, to people- and object-tracking in both cooperative and hostile environments. The focus is on the development low-power and energy harvesting platforms, energy-efficient real-time operating systems design, lightweight asynchronous and synchronous wireless protocols and distributed consensus algorithms for in-network processing and macro-programming.

Each discussion-oriented lecture is preceded by students reading 1-2 papers, resulting in a rich foundational body of knowledge by the end of the semester. I teach the programming of sensor nodes by using the nano-RK power-aware sensor real-time operating system (RTOS) and IEEE 802.15.4 radio communications with hands-on exercises. Project groups define, design, implement and test new architectures for future WSAN. The course includes guest lecturers by experts from the field and engineers from embedded systems such as ARM, Freescale, Tektronix and Texas Instruments.

C. Model-based Systems Curriculum Development

In addition to teaching these courses, I have also been actively working on developing a curriculum for Model-based Design and Engineering to augment the university's current offerings in Computer Engineering and Embedded Systems Masters programs. This curriculum will allow the student to journey from specifications to models to implementations to integration for rigorous system design of controls, computation and communication. With applications in physiological control systems (BME), automotive powertrain systems (MEAM), industrial automation processes (ESE), and cloud-enabled energy management systems (CIS), this curriculum will invite students and faculty across departments. While the general approach to such a broad class of problems is to strive toward *everyone knows everything*, my approach to this educational challenge, in collaboration with George Pappas, is that *everyone views everything as a system*. I am working to meet the increasing need for such "system-level thinking" across our department.

A systems view of computing is only currently emerging, resulting in the rapidly growing fields of Model-based Systems and will include elements of:

- Formal methods for modeling systems that are correct by construction with explicit guarantees for functional correctness of timing and safety and para-functional correctness of attributes such as energy and efficacy.
- Integrated approaches for model abstractions and refinements for sub-system verification and composition of system components.
- Languages for system-level specification and model translation for simulation based testing of behavioral and performance requirements
- Automatic code generation and platform-level conformance testing methods
- Semantic interfaces for guarantees and adaptation between controls, communication and computation elements
- Industrial case studies involving avionics, nuclear, medical and automotive standards for safety critical systems.

D. SEAS+PennDesign Cross-School Curriculum Development

My educational efforts have also been directed at integrating innovative work between schools at Penn, recognizing that such collaboration can yield new approaches to emerging media technologies. From January 2014, I will direct the new MediaLab@Penn, a Collaborative Center for Entertainment Technology and Experience Design, funded by Comcast. A curriculum for integrated product and experience design is being developed with Sarah Rottenberg and William Braham from the School of Design to integrate coursework, projects and student teams across SEAS and Design. Currently, the IPD509 Need Finding course in Design and ESE350 will jointly focus on the design and technology elements of projects in the MediaLab@Penn. This new approach for cross-school education will give students (and faculty) experience in holistic design from concept to product.

E. Student and Faculty Development through Teaching

I have concentrated my efforts not only in teaching undergraduate and Masters students foundational skills in embedded systems engineering, but also in providing them with opportunities in research to develop them into future contributors to the field. Many students consider ESE350 and ESE519 as a stepping-stone toward a successful career in research and development. In the past five years, I have actively involved over 41 undergraduates and Masters students in research, each for at least a year after taking my course. I have consciously aimed to provide opportunities to female and underrepresented students, several of whom have proceeded to graduate studies. For example, Allison Connolly'11 was co-author on three international conference papers on medical devices and won an NSF Graduate Fellowship. Stephanie Diaz'12 helped develop the ProtoDrive Electric Vehicle platform that won the top prize in the 9th World Embedded Systems Competition, Korea. Kevin Conley'10 and George Chen'13 both won the SEAS Best Summer Research Prize.

These efforts in developing impactful teaching strategies have evolved within student as well as faculty learning environments. Within SEAS, I have co-hosted an Engineering Faculty Teaching Forum to share stories and insights on *Active Learning in and beyond the classroom* with fellow faculty members. I have also given a talk at the Engineering Dean's Advisory Board on *Getting Involved in Undergraduate Research.* Recently, I participated in the Engineering Deans' Advisory Board Professor Video project to encourage more prospective students to apply to Penn Engineering.

Teaching Outreach

While my teaching and curricular efforts have largely focused on students within Penn, I recognize that a successful educational program must speak to wider academic communities. In the process, I have sought to establish Penn as a recognized force across global engineering communities. Beyond Penn, I have mentored teams in the Young India Fellowship Program (Penn is an academic partner) to develop technology for handicapped persons. The ViSparsh team co-developed the Haptic Belt for the Blind and went on to win the Grand Finale Prize in the 2012 Accenture Innovation Jockeys Competition, the 1st Prize in the Health 2.0 Conference 2012 and won the Best Project Prize at the Young India Foundation.

F. Teaching Style

To keep students engaged, many teachers use comedy; I use drama. By framing each module as a compelling conflict between different entities, I guide my students through the set of obvious yet subtle resolutions. This approach has a habit of making the lecture take on its own route and has made me realize the importance of preparation. I have since begun to follow a simple rule-of-thumb, where for a well thought through lesson plan I must invest at least a day for each lesson hour. All assignments are delivered in the form of a mission from a customer, for instance as a flight-coordinator at NASA, the lead-designer from OTIS Elevator and so on. This gives the students both a sense of ownership and a concrete idea of the relevance of the skills they are learning.

Undergraduates and MS Students Mentored: **National and International Awards**

All student awards are from projects done in my ESE350 & ESE519 Embedded Systems courses

1. **1st Prize Winner of SEAS Senior Design Project.** 2012
   Pacemaker Verification System
   Varun Sampath CE'12, Shilpa Sarode EE'12 and Sriram Radhakrishnan CE'12

2. **Intel Innovators $50K Award.** 2012
   Haptic belt for the blind
   Eric Berdinis CE'12 and Jeff Kiske, CE'12

3. **1st Prize** in **9th World Embedded Software Competition (Medical Devices), Korea**. 2012
   Korean Ministry of Knowledge Economy and Electronics and Telecommunications Research Institute (ETRI)
   Varun Sampath CE'12, Shilpa Sarode EE'12 and Sriram Radhakrishnan CE'12)

4. **1st Prize** in **Honeywell User Group OneWireless Competition.** 2011
   Awarded for innovation in next-generation of wireless control for industrial automation
   Harsh Jain, EMBS and Miroslav Pajic, Ph.D.

5. **1st Prize** in **8th World Embedded Software Competition, Korea.** 2010
   Korean Ministry of Knowledge Economy and Electronics and Telecommunications Research Institute (ETRI)
   Kevin Conley CE'12 and Madhur Behl, Ph.D.

6. **3rd Prize** in **9th World Embedded Systems Programming Contest, Seoul, Korea.** 2012
   ProtoDrive Electric Vehicle Platform
   William Price EE'12, Harsh Jain EMBS, Yash Pant MSEE'12

7. **IEEE President's Award, Finalist.** 2012
   Pacemaker Verification System
   Varun Sampath CE'12, Shilpa Sarode EE'12 and Sriram Radhakrishnan CE'12

8. **Honorable Harold Berger Award for Best ESE Senior Design Project.** 2012.
   Pacemaker Verification System
   Varun Sampath CE'12, Shilpa Sarode EE'12 and Sriram Radhakrishnan CE'12

9. **People's Choice Award** - **Intel/Cornell Embedded Systems Cup.** 2012
   Haptic belt for the blind
   Eric Berdinis CE'12 and Jeff Kiske, CE'12

10. **Project Award** - **Intel/Cornell Embedded Systems Cup.** 2012
    HAWK: Helicopter Aircraft Wielding Kinect
    Kevin Conley CE'12, Matthew Hale CE'12, Paul Gurniak CE'12 and Theodore Zhang CE'12

11. **Honorable Mention Award** for **Senior Design Project.** 2012
    HAWK: Helicopter Aircraft Wielding Kinect
    Kevin Conley CE'12, Matthew Hale CE'12, Paul Gurniak CE'12 and Theodore Zhang CE'12

12. **Frederick Ketterer Memorial Award** for **Best Senior Design Project.** 2011
    RAVEN: Remote Aerial Vehicle for Search and Rescue
    Paul Martin EE'11 and William Etter Jr. EE'11, MSEE'12

13. **Health 2.0 conference Winners.** 2012
    viSparsh: Haptic belt for the blind
    Jatin Sharma, Tushar Chugh, Rolly Seth of the Young India Fellowship Program (Penn Partner)

14. **Winner** of **1st Prize Senior Design Award, CIS Department**. 2011
    AutoPlug: Automotive Architectures for Remote Vehicle Controls Testing
    Gabriel Torres CIS'11, Ross Boczar EE'11 and Jason Suapengco CIS'11

15. **2011 Google Zeitgeist Young Minds Award**
    HAWK: Helicopter Aircraft Wielding Kinect
    Kevin Conley CE'12, Matthew Hale CE'12, Paul Gurniak CE'12 and Theodore Zhang CE'12

16. **Grand Finale Winner** in the **2012 Accenture Innovation Jockeys (Powered by Yahoo!)**
    viSparsh: Haptic belt for the blind
    Jatin Sharma, Tushar Chugh, Rolly Seth of the Young India Fellowship Program (Penn Partner)

17. **Honorable Harold Berger Award for Best ESE Senior Design Project.** 2009

Vehicular Communications for Safety
Danny Lustig EE'09, Andrew Avrin EE'09 and Brandon Duick EE'09

Undergraduates and MS Students Mentored: **Conference Publications**

(Undergraduate and MS students are underlined)

1. S. Diaz, H. Jain, Y. Pant, W. Price and R. Mangharam. "ProtoDrive: An Experimental Platform for Electric Vehicle Energy Scheduling and Control" 33rd IEEE Real-Time Systems Symposium (RTSS@Work). Puerto Rico, Dec 2012.
2. W. Etter, P. Martin, and R. Mangharam, "Cooperative Flight Guidance of Autonomous Unmanned Aerial Vehicles". *CPS Week Workshop on Networks of Cooperating Objects (CONET)*. April 2011.
3. U. Drolia, Z. Wang, Y. Pant and **R. Mangharam**. "AutoPlug: An Automotive Test-bed for Electronic Controller Unit Testing and Verification". *Intelligent Transportation Systems* (ITS). October 2011.
4. Z. Jiang, A. T. Connolly and **R. Mangharam**. "Using the Virtual Heart Model to Validate the Mode-Switch Pacemaker Operation". *32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. August 2010.
5. Z. Jiang, M. Pajic, A. T. Connolly, S. Dixit and **R. Mangharam**. "Real-time Heart Model for Implantable Cardiac Device Validation and Verification". *22nd Euromicro Conference on Real-Time Systems,* (IEEE ECRTS). July 2010.

Undergraduates and MS Students Mentored: **Conference Posters and Demos**

(Undergraduate and MS students are underlined)

1. N. Shah, L. Vadakedathu, D. Wheeler and R. Mangharam, "EnRoute Energy Router: Building HVAC Test-bed". Demo and Poster at *IEEE/ACM CPSWeek*. April 2013.
2. V. Sampath, S. Sarode, S. Radhakrishnan, Z. Jiang, M. Pajic and R. Mangharam. "Pacemaker Verification System". Demo and Poster at *IEEE/ACM CPSWeek*. April 2012.
3. U. Drolia, Z. Wang, S. Vemuri, M. Behl and R. Mangharam. "AutoPlug - An Automotive Test-bed for ECU Testing, Validation and Verification". Demo and Poster at *IEEE/ACM CPSWeek*. April 2011.
4. P. Martin, W. Etter and R. Mangharam, "R.A.V.E.N. - Remote Autonomous Vehicle Explorer Network". Demo and Poster at *IEEE/ACM CPSWeek*. April 2011.
5. Z. Jiang, M. Pajic, A. T. Connolly and R. Mangharam. "A Platform for Implantable Medical Device Validation". Demo and Poster at *Wireless Health Conference*. October 2010.
6. M. Pajic, Z. Jiang, A. T. Connolly and R. Mangharam. "A Framework for Validation of Implantable Medical Devices". Demo, Poster and Work-in-Progress paper at *IEEE/ACM CPSWeek*. April 2010.

Undergraduates and MS Students Mentored: **Open Source Embedded Systems Artifacts**

1. *ProtoDrive*: An Experimental Platform for Electric Vehicle Energy Scheduling and Control. http://mlab.seas.upenn.edu/protodrive/ (2012-Present)
2. *En-Route Energy Router:* Energy-Efficient Building Control and Scheduling Test-bed (2010-Present)
3. *Open-ISA100.11a*: Open software stack for standardized industrial wireless control automation. http://mlab.seas.upenn.edu/openisa/ (2011-Present)
4. *Pacemaker Verification System:* Platform for closed-loop testing and verification of medical devices. http://pvs.medcps.org/ (2012-Present)
5. *HAWK:* Platform for Helicopter Aircraft Wielding Kinect for search and rescue in buildings (2012)
6. *Haptic Belt for Blind:* Platform for indoor and outdoor guidance for blind persons (2011-Present)

7. *AutoPlug*: Open Automotive Architecture for Plug-n-Play Services. Open-source software at http://www.autoplug.org/ (2011-2013)
8. *AirHacks:* Open Unmanned Aerial Vehicle Platform (Quadrotor) at http://airhacks.org/ (2011-2013)

Undergraduates and MS Students Mentored

1. **Harsh Jain***, MS, ESE.* Wireless Control for Industrial Automation and ProtoDrive: Electric Vehicle Test-bed. Winner of Honeywell Wireless Control Automation Award, 2011. 3rd Prize in World Embedded Programming Competition, Korea. 2012. Distinguished Recognition Award in Intel/Cornell Embedded Systems Cup 2013.
2. **William Price***, Senior, EE & MEAM,* ProtoDrive: Electric Vehicle Test-bed. 3rd Prize in World Embedded Programming Competition, Korea. 2012.
3. **Tao Lei***, MS, ESE.* Traffic Signal Scheduling in Philadelphia. Also developed Cloud Services for MLE+ for energy-efficient building modeling and control. 2012-13.
4. **Neel Shah***, MS, Embedded Systems.* En-Route 2.0 Energy Test-bed for Energy Efficient Buildings. 2012-13.
5. **Praveen Pitchai***, MS, Robotics.* Vision Integrated Operating System for Comcast Cable Set-top box of the future. Computer vision and machine learning. 2012-13
6. **Rajeev Kumar***, MS, Robotics.* Vision Integrated Operating System for Comcast Cable Set-top box of the future. Cloud-based interactive processing. 2012-13
7. **Abhijeet Mulay***, MS, Embedded Systems.* ProtoDrive: Electric Vehicle Test-bed. Finalist for Intel/Cornell Cup for Embedded Systems. Developed ZipCare: a wearable wireless EKG heart-monitoring patch. 2012-13.
8. **Shadhidhar Reddy***, MS, EE.* Vision Integrated Operating System for Comcast Cable Set-top box of the future. Platform architecture and immersive experience. 2012-13
9. **Rajib Dutta***, MS, Embedded Systems*. ZipCare Wearable Heart and Activity Monitor. 2012-13. Now at Windows Embedded Team, Microsoft.
10. **Tanvir Ahmed***, Junior, Computer Engineering.* Vision Integrated Operating System for Comcast Cable Set-top box of the future. User interface and interaction. 2013.
11. **Alfredo Muniz***, Sophomore, Computer Engineering.* ProtoDrive: Electric Vehicle Test-bed. 2013.
12. **Parth Patel***, Freshman, Electrical Engineering.* ProtoDrive: Electric Vehicle Test-bed. 2013.

Undergraduate Senior Design and MS Thesis

1. **Azriel Samson***, MS, Embedded Systems.* Open-source ISA100.11a network stack for industrial automation. 2012-13. http://mlab.seas.upenn.edu/openisa/
2. **Vignesh Subramanian,** *MS, Embedded Systems.* Open-source ISA100.11a network stack for industrial automation. 2012-13. http://mlab.seas.upenn.edu/openisa/
3. **Eric Berdinis***, Senior, CE.* Winner of Google Zeitgeist Award, Intel Innovators Award, Intel/Cornell Embedded Systems Cup – People's Choice Award.
4. **Jeff Kiske***, Senior, CE.* Winner of Intel Innovators $50K Award; Cornell Embedded Systems Cup – People's Choice Award. 2011-2012.
5. **Chen Zheng***, MS EE.* Electricity Controller Cloud Architecture. 2011-12.
6. **Haofang Yuan***, MS EE.* SolarSkin for Energy Efficient Buildings. 2011-12.
7. **Chenyan Sun***, MS EE.* Design and development of the ISA 100.11a Wireless Standard for Industrial Automation. 2011-12. http://mlab.seas.upenn.edu/openisa/

8. **Varun Sampath**, Senior, CE. Winner of SEAS 2012 Senior Design Competition. Winner of Honorable Harold Berger Senior Design Project Award, 2012. Grand Prize Winner, World Embedded Competition, Korea, 2012.
9. **Sriram Radhakrishnan***, Senior, ESE.* Winner of SEAS 2012 Senior Design Competition. Winner of Honorable Harold Berger Senior Design Award, 2012. Grand Prize Winner, World Embedded Competition, Korea, 2012.
10. **Shilpa Sarode***, Senior, ESE.* Winner of SEAS 2012 Senior Design Competition. Winner of Honorable Harold Berger Senior Design Project Award, 2012. Grand Prize Winner, World Embedded Competition, Korea, 2012.
11. **William Etter***, Senior, ESE.* Awarded Vagelos Undergraduate Research Grant. Winner of Frederick Ketterer Memorial Award for Best Senior Design Project 2011. http://airhacks.org/
12. **Theodore Zhang***, Senior, ESE.* Intel/Cornell Embedded Systems Cup Winner 2012. Honorable Mention Award, SEAS Senior Design Competition 2012.
13. **Kevin Conley***, Senior, ESE.* Awarded Rachleff Scholar Scholarship. Awarded 1st Prize in World Embedded Software Competition, Korea, November 2010.
14. **Paul Martin***, Senior, ESE.* Awarded Vagelos Undergraduate Research Grant. Winner of Frederick Ketterer Memorial Award for Best Senior Design Project 2011. http://airhacks.org/
15. **Gabe Torres***, Senior, CIS.* Winner of 1st Prize Senior Design Award, CIS Department 2011.
16. **Ross Boczar***, Senior, ESE.* Winner of 1st Prize Senior Design Award, CIS Department 2011.
17. **Jason Suapengc***, Senior, CIS.* Winner of 1st Prize Senior Design Award, CIS Department 2011.
18. **Anu Sukumaran***, MS, ESE.* First job at Lutron Electronics.
19. **Utsav Drolia***, MS, ESE.* Now Ph.D. student at Carnegie Mellon University.
20. **Danny Lustig***, Senior ESE.* Winner of Harold Berger Senior Design Project Award, 2009. Ph.D. at Princeton University.
21. **Andrew Avrin***, Senior ESE.* Winner of Harold Berger Senior Design Project Award, 2009. Now at Google.
22. **Steven Z. Wang***, MS, ESE***.** Developed Real-Time Link Protocol. First job at Motorola, Michigan
23. **Srinivas Vemuri***, MS, ESE.* Developed Embedded Virtual Machines. First job at GE Healthcare, Milwaukee
24. **Mansimar Aneja***, MS, Robotics.* Developed EnRoute: Energy Router for Peak Power Management in Buildings. First job at BOSCH Research (Pittsburgh).
25. **Brandon Duick***, Senior, EE,* Winner of Harold Berger Senior Design Project Award, 2009. At Lockheed Martin.
26. **Jason DeLisser,** *Senior, EE, 2010***.** Joined US Naval Research Center.
27. **Avinash Rajput***, Senior, EE, 2009.* First job at MERK, Automation Division.
28. **Sunil Sadasivan** (Cisco), 2010. CTO of Buffer.com

Undergraduate Summer REU Students

1. **George Chen**, Johns Hopkins University, Biomedical Engineering. 2013
   - Won Best Summer Research Award in SEAS**.**
   - Selected for CRA Engineering Education Awardees Conference, Oct 2013.
2. **Stephanie Diaz**, SUNY Binghamton, Electrical Engineering. 2012
   - Developed ProtoDrive: Electric Vehicle Platform.
   - Published research in 33rd IEEE Real-Time Systems Symposium, Puerto Rico, 2012.
3. **Kevin Conley**, Penn, Electrical & Systems Engineering. 2012
   - Awarded Rachleff Scholar Scholarship.
   - Won Best Summer Research Award in SEAS.
   - Won 1st Prize in World Embedded Competition, Seoul, Korea in 2010 for the AutoPlug project.
   - Now pursuing Ph.D. in Stanford.
4. **Peter Malamas**, Johns Hopkins University, Biomedical Engineering. 2011
   - Developed 3D Electrophysiological Heart Model for Real-time Interaction with Pacemakers.
5. **Uchenna Kevin Anyanwu**, California State University at San Jose, Electrical Engineering. 2009.
   - Developed GrooveNet 3.0 Vehicular Network Simulator.
   - Now pursuing a Ph.D. at Virginia Tech.
6. **Allison Connolly**, Johns Hopkins University, Biomedical Engineering. 2009-10
   - Developed the Real-Time Heart Model.
   - Pursuing a Ph.D. at U. Minnesota, 2010.
   - Selected for NSF Engineering Education Awardees Conference, Jan 2010.
   - Co-authored three papers in IEEE ECRTS, IEEE EMBC and RTAS