## Spring 2009 Mentors

### Inactive Mentors

The following mentors are from past semesters, or will not be taking new mentees this semester. If you are looking for Mentors who will be recruiting for this current semester, see the [Active Mentor Listing](#).

### Prior Mentors in the PURE Program:

<table>
<thead>
<tr>
<th>Active?</th>
<th>Photo</th>
<th>Mentor</th>
<th>Research / Project Summary</th>
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</thead>
<tbody>
<tr>
<td></td>
<td><img src="image" alt="Aaron Becker - Robotics and Control" /></td>
<td>Aaron Becker - Robotics and Control</td>
<td>Project 1: Design and build a controller to balance a steel ball on a wheel, using a distance sensor and DC motor. Project 2: Design and build a LabVIEW controller for a Rhino robotic arm.</td>
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<td></td>
<td><img src="image" alt="Abhinauv Kapoor - Signal Processing, Comm." /></td>
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<td>I am working on speech cues that enable humans to listen and understand syllables in the english language. The research requires small modification to speech in time and frequency, and collection of data from listeners of modified speech. The goal is to get a better understanding of our ability to hear and interpret speech. My current goal is find the thresholds of some of the cues and how those can be changed to better our hearing.</td>
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Possible topics for undergraduate research projects:
David Estrada - Physical Electronics

- Device Characterization
- Thermal Imaging of Suspended Thin Films
- Thermal Imaging of Carbon Nanotube Networks and Aligned Arrays
- Development of LabView Programs for Device Characterization

Our group is focused on power dissipation in low dimensional systems (1-D and 2-D structures). If you have experience or interest in semiconductor characterization we can tailor your project to meet your interest.

Elizabeth VanRuitenbeek - Computer Security

Possible topics for undergraduate research projects:

- botnets (models/simulation)
- phone viruses (propagation; mitigation techniques)
- mobile device sync software (virus transmission)
- economic aspects of computer security (monetary incentives for compromising computer security; monetary costs of security measures)
- virus/vulnerability black markets
- user aspects of computer security
- effectiveness of computer security education for the masses
- password security; password cracking
- security metrics
- privacy (Europe vs. US)
- smartcard security
- security of identity management systems

We can tailor the project to the particular computer security interests of the mentee. Let me know what interests you!

Erik Johnson - Engineering Education

We would ideally like to work with the mentee to develop a project related to ECE 110. Suggested projects include analysis of our ECE 110 quantitative data. Specifically, this involves building statistical models, such as multivariate linear regressions, of student performance. Mentees could also get involved in the analysis of qualitative data from the team leaders. This involves close reading and coding of journals and surveys from team leaders.
For my master's thesis, I researched polyphonic (multiple notes playing at a time) pitch detection. The project was done primarily with Matlab and was part of a larger project where we are trying to "demix" music back into the original recording tracks so we can eliminate or add more instruments to the mix, remix the music to our own liking, and devise creative new ways to use surround sound systems (i.e., have each instrument play from a different speaker).

My current research project is completely different and revolves around the undergraduate learning experience. We are currently investigating what makes introductory level computer engineering/science courses (such as ECE 190, ECE 290, CS 231, CS 125, CS 173, etc.) hard for students to learn and how we can help students learn these courses better. This research will be used to develop tools to help refine how these courses are taught both at the University of Illinois and at other schools.

Research topics:
- Multi-level security systems
- High assurance workstations
- Virtualization (Xen, KVM, ...)
- Formal methods for security verification
- Trusted O/S
- Trusted IO and graphics
- Information leakage detection and information flow analysis
- Covert channels (analysis and prevention)
- Secure hardware support (TPM chips) for all of the above

Mentees can choose the topic that interests them. Promising results will be published.

My current research is focused on analysis and design of antennas. I am using a method called Characteristic Modes to design and analyze the behavior of antennas. Right now, I am studying electrically small antennas and I plan to eventually extend this to multiport antennas and possibly others. In addition to performing analytical and numerical analysis on these antennas, we also build and test them.

Project title: Controlling chaos: exploiting insensitivity in stochastic systems

More information: visit my web page.
Possible projects:
1. Select a robotic platform (e.g., one of the various robots in our lab) and develop the model for the system. Apply the optimization technique already developed in our lab (called SHOT) to the system and implement it on the robot.
2. Select an interesting stochastic system that is suitably complex and outside of robotics, such as financial systems, crowd control, weather control, disease propagation and control, etc. The student would develop a model for the system and then use SHOT to find a solution for the problem.
3. Simulate various perturbations to some system model to determine the sensitivity of the system due to variations in the description of the system. This empirical information will be used to buttress theoretical results.
4. Extend SHOT by
   a. exploring and implementing new methods within the optimization technique
   b. optimizing the code
   c. modifying the code to run in parallel on the Turing cluster

Students may select related projects.

Matt Johnson - Computer Architecture

My current research is focused on the development of a 1000-core processor, libraries and other system software to facilitate programming it, and emerging applications that can take advantage of this massive parallelism. The project website can be found here: http://rigel.crhc.uiuc.edu

I have broad experiences and interests, ranging from autonomous vehicles to graphics, circuit design and parallel programming. We can work together to find a project which is interesting to both of us. In nearly all cases, some programming experience will be required to complete a substantial project, but critical thinking skills are far more important than any particular language or framework.

Quanyan Zhu - Game Theory and Control Systems

There are multiple projects available:
1) An investigations on algorithms for solving non-cooperative games with coupled constraints
2) Design of control policies for optimal intrusion detection systems
3) Game-theoretical modelling of intrusion detection systems
4) Robust and secure control design of distributed networked systems in malicious environment
5) Application of sum-of-squares in control system analysis and design

I also encourage students to find their own topics within my scope of interest.

Sensor networks: Sensors are devices that can sense their local environment and make quantitative measurements. For example, thermometer is a sensor that senses temperature and a barometer is a sensor that measures pressure. Wireless sensor networks are networks of small low cost sensors that can communicate over the wireless medium and also have processing units. Essentially you have a network of dime-sized, and priced, computers that can communicate over the wireless medium and also sense the temperature, pressure or some other quantity of interest.
Project: The ultimate goal of the project is to set up a network testbed of heat sensors that will identify the location of a heat source. The idea is to have a large sheet of some conducting material that is heated by the tip of a soldering iron. Sensors will be attached to sheet that will measure the temperature at different locations. These measurements have to be processed to obtain the location of the soldering iron.

The idea is to create a miniature factory shop floor [represented by the metal sheet] where sensors are deployed at different locations in the room [different locations on the sheet]. Often malfunctioning of machines are accompanied by heating [represented by soldering iron tip]. The goal is to determine the faulty machine [represented by the location of the soldering iron].

My research is centered around high dimensional data clustering and analysis. I primarily work in developing nonparametric algorithms for detecting interesting clusters and patterns in high dimensional data. I also work on developing supervised and semi-supervised ML algorithms that bootstrap on structures detected by unsupervised learning methods.

There are two possible projects for this Spring:

1. Digital Analysis of Art: My mentees last semester collected a good dataset of paintings from a variety of sources as part of their project. The project this semester will focus on applying new feature extraction techniques based off "sparse representation" theory and distance metric learning algorithms to obtain interesting visualizations of artistic styles.

2. Clustering Biological Data: We will explore the landscape of clustering algorithms and their use in analyzing high dimensional biological data. I expect this to be a challenging project and pretty open ended in terms of what the mentee and I choose to explore.

My research interest is on the use of light in nanostructure characterization. Currently I am fleshing out the details of a high speed ellipsometer that we recently proposed and over the fall I will be building and testing it. However, mentees do not have to be a part of this effort for there are several small fun problems to work on. Two of them are listed below and you can discuss more by sending me an email. If you have any problem that you want to work on, that is also all right.

1. Optical Tweezer: Optical tweezers use light to manipulate small particles. In this project, mentees will analyze the forces acting on a nanoparticle trapped by an optical tweezer as the particle is moved from one medium to the other.

2. Vector beam characterization: Vector beams are optical beams which have different polarization at different points of the beam. In this project, mentees will write computer code to analyze experimental data collected for analyzing vector beams.

There are 2.5 possible projects:
1) An investigation of networked control system. The question here is: how does delay, packet loss, multi-path routing and other issues in an unreliable
network affect the performance of feedback control system.

2) Analysis of Hidden Markov Model (which is used widely in many areas such as signal processing, communication, economics.. ). We focus on computing the entropy rate of HMM.

2.5) I also want to do something about compressed sensing. Interested students can contact me to discuss details about this topic.

Students are encouraged to find their own topics as long as they do not deviate too much from the theme.

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Taylor Johnson - Controls

Last semester my PURE mentees worked on a project modeling a DC-to-DC buck converter in the hybrid system modeling tool/language PHAVer. I would like to continue this work and expand upon the results, as it was close to a novel, and practical, application.

As for myself, this semester I am working on two projects. One involves analysis of an inverted pendulum and the other involves a timing guaranteed programming language, such as Henzinger, Horowitz, and Kirsch's Giotto (http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.22.8471). Mentees could potentially provide programming support on these projects.