Fall 2016 Mentors

Below are the Graduate Mentors in the PURE Program.

Electrical and Computer Engineering

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<th>Minji Kim</th>
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Brief summary of my research:
I am a 5th year PhD student in the Electrical and Computer Engineering department, working with Professor Olgica Milenkovic and Professor Jun Song. My research interests are in bioinformatics and computational biology, specifically in processing and analyzing genomic data using tools from information theory and machine learning. In particular, I have developed tools to prioritize “disease” genes, compress next-generation sequencing data, and a model to predict the likelihood of DNA sequences to fold into secondary structures.

Possible projects for mentees:
The mentee will have the flexibility to choose a research project that aligns with his or her interest, with full support and help from the mentor. Possible projects include: 1) designing efficient algorithms to count words of length k, 2) compressing genomic data, 3) detecting peaks of time series data.

Prerequisites/extra information:
The proposed projects will require knowledge of algorithms, machine learning, and the ability to implement them. Desired skills are: 1) fluency in one of Python, Java, C, MATLAB, 2) basic probability theory (ECE 313), 3) willingness to work with biological data.

Additional Questions for Applicant
1) On average, how many hours a week can you commit to this project?
2) What was your favorite engineering course at UIUC, and why?
Xiao Ma

I’m a 5th year graduate student conducting research in stochastic electromagnetic interference analysis and high-speed circuit interconnect modeling under the supervision of Prof. Cangellaris.

Possible Projects:
Investigation of the statistics of the electromagnetic response of a dynamic multi-mode cavity using numeric field solver.

Desired Coursework/Experience:
Basic knowledge of electromagnetics (PHYS212, ECE329) and moderate familiarity with probability (ECE313) would make your life easier and guarantee a beneficial educational experience. Experience with computer aided design tools a plus.

Your schedule should allow an hourly meeting, and approximately 5-10 hours to work on the project per week.

Additional Questions for Applicant
What do you expect from the PURE program?

Wen Huang

Possible Projects:
The selected students will go through the MNTL cleanroom training and hand-in-hand in-group nano-fabrication training. Students will focus on certain major fabrication steps like lithography, thin film growth, or metal evaporation. They are expected to spend most of the time to focus on understanding the fabrication mechanism and optimizing the fabrication quality. They will work as a team to finish at least one entire project at the end of PURE program. Their research contribution will be highly appreciated and published as co-author if it is good enough.

Desired Coursework/Experience:
Mentee’s Commitment:
Research Area: Nanotechnology, Radio frequency integrated circuit and system

Research Advisor: Xiuling Li

Contact: whuang82@illinois.edu

I am currently a Ph.D. candidate working in Prof. Xiuling Li’s group in the ECE department. My research focus on self-rolled-up-nanomembrane (S-RuM) nanotechnology for the applications in RFICs/MMICs. Generally speaking, S-RuM nanotechnology provides a smart way that is able to make RFIC/MMICs much more compact with greatly enhanced performance. Its practical application covers a wide range like individual circuit components, IoT (Internet of Things) wireless /sensor chips, 5G and beyond next generation wireless communication, etc. You can find more information about S-RuM nanotechnology by clicking the link: https://publish.illinois.edu/ece-wenhuang/. We now have 7 people doing research in this area, and I am the leading student. We started 4 years ago from very basic material search level to now a practical circuit integration level. During the past 4 years, we published more than 10 high quality journal/conference papers and have applied for 7 US patents (3 issued so far). Our search is reported in many media and funded by several agencies. Due to more research work is desired to refine the S-RuM nanotechnology, we are now looking for undergraduate research assistants with matching background to join us.

5 or more hours per week, but flexible as long as the assigned task is done by the end of semester.

Requirements/Qualifications for Mentees:


B. It is suggested mentee could work with us at least one year as the training itself takes some time. Mentee may need one year to fully finish the assignment.

C. Face to face interview may require.

Additional Questions for Applicant

A. How would you describe yourself? (Anything is fine, like you can talk about yourself in daily life or academic activities)

B. What do you plan to do after graduation?

C. Please describe as much as you can – what is the most important RFIC on-chip passive device? And why?

Please send you answer and your CV to whuang82@illinois.edu. The subject line is: “PURE_your name”
My name is Yi Song. I am a Ph.D student in Prof. Xiuling Li’s group in ECE department. My main research focuses on electronic devices and nanotechnology, primarily on nanoscale transistor design and fabrication. Fabricating transistors using III-V materials is fundamental for aggressively scaled transistors due to their high motilities. Other than conventional top-down etching method for device fabrication, we have capabilities in fabricating transistors in novel ways, either by bottom-up selective area growth or metal-assisted chemical etching. New process flows for advanced 3D device architectures, such as III-V FinFETs and Gate-all-around nanowire transistors were developed. From the experimental demonstration and theoretical investigation, novel device characteristics and their scaling behaviors were discovered, which may have great potential for practical applications.

Possible Projects:

Ultra-high density 3D vertical transistors by metal assisted chemical etching with damage-free channel surface;

MOS capacitance fabrication by metal-assisted chemical etching and its interface states characterization;

FinFET/ultra thin body transistor by bottom-up selective area growth technique.

Desired Coursework/Experience:

Familiar with semiconductor device physics, Prerequisite courses ECE340, ECE488

Familiar with IC device theory fabrication, Prerequisite course ECE444

Familiar with nanotechnology, better if know how to operate equipments and have cleanroom access

Additional Questions for Applicant

Are you interested in semiconductor device and nanofabrication?

Are you dedicated to devote yourself to experiments, promote new ideas and consistent to try?

Are you willing to help others if collaborating with others?
I am a sixth year graduate students under Jonathan Makela in the Remote Sensing and Space Sciences group. Our group does everything from modeling, to instrument design, to data collection and analysis in the study of the upper atmosphere. I mainly focus on data analysis using the passive optical instrumentation we have deployed to study the thermospheric neutral winds and temperatures.

Possible Projects:
The project you could be working on is creating/using a machine learning algorithm to detect and flag potential bad data taken by our instruments. This data product is used by other researchers around the world and having higher quality data will actually help many in their research!

Desired Coursework/Experience:
Experience with python desired, but not required

Additional Questions for Applicant
None

Xu Chen

Possible Projects:
Stochastic electromagnetic and circuit analysis – For this project, we will simulate a high-speed USB-C channel to study its performance and bit-error-rate (BER). We are interested in how the uncertainties in the cable, connectors, etc. affect the performance of data transmission through the link. The student is expected to learn how to model transmission lines and other channel structures with commercial electromagnetic solvers, and to learn how to simulate a high speed signaling channel using commercial circuit solvers. The final deliverable will be a statistical study of the channel performance with presence of uncertainties. This will involve Monte Carlo analysis and other fast stochastic numerical techniques.

Desired Coursework/Experience:
Credit for ECE 210, credit or concurrent registration in ECE 313 and ECE 329. Programming experience with MATLAB or Python is a plus. Experience with DSP a plus.

Additional Questions for Applicant
a) What courses are you registered for in Fall 2016?
b) Are you willing/able to have research meeting on weekends?
I am a fifth-year Ph.D. student in ECE co-advised by Prof. Andreas Cangellaris and Prof. Jose Schutt-Aine. My research is in the area of stochastic modeling for electromagnetics and signal integrity applications. I invent and develop simulation methodologies and tools that allow computer system designers to simulate the signaling performance of their designs even when some input parameters or the exact system is uncertain. Traditionally, these analysis are performed using time-consuming Monte-Carlo sampling methods. My work in Stochastic Collocation and Stochastic Galerkin methods have allowed the same analysis to be performed much faster.

I am currently an instructor for ECE 329. I have been on the UIUC List of Excellent Teachers every semester I was an instructor or TA. I am a College of Engineering Mavis Future Faculty Fellow, and I am also the recipient of the E. A. Reid Fellowship and H.L Oleson Award for outstanding undergraduate teaching.

I received my B.S. from ECE ILLINOIS in 2005. From 2005-2012, I was a Signal Integrity Engineering with IBM Systems & Technology Group in Poughkeepsie, NY, working on mainframe, supercomputer, and workstation systems. In summer of 2013 and 2015, I was an intern at Apple Inc. in Cupertino, CA, working on Electronic Design Automation. This is my sixth time mentoring PURE. In each of the last five semesters, one of my mentees has won an award at the PURE Symposium each time. Two of my mentees have published their PURE research in IEEE conference papers.

c) What is your area of interest in ECE and what do you plan to do after graduation?
My research is in the area of computer security. In particular, I focus on improving security monitoring and intrusion detection techniques for enterprise and cloud systems. One of the major problems in enterprise security today is the sheer volume and diversity of data that must be analyzed to detect attacks. Collecting, storing, and analyzing this information is expensive, and identifying which data are important for intrusion detection is difficult. The burden falls on system administrators and security analysts, who must use their domain knowledge to manually adjust system monitoring as attacks are missed and monitor data goes unused. Often, security incidents go undetected until after their effects are felt by users, and in some cases, existing monitoring proves insufficient to easily identify the root cause of the incident, delaying efforts to restore system operation and patch vulnerabilities.

In previous work, I devised a methodology to help administrators determine the optimal set of security monitors to deploy in a system. This work recently won the Best Paper Award at the 2016 IEEE/IFIP International Conference on Dependable and Secure Systems (DSN 2016). My previous work assumes the presence of information about the utility of monitor data that may not be easily available; to account for that, in my ongoing research, I am using data-driven approaches to identify relationships in the data that would aid in intrusion detection, which I plan to use in determining optimal monitor deployments. I am also investigating data-driven techniques to identify potential intrusions as early as possible during the operation of a system and preemptively increase monitoring.

Possible Projects:
All of my project plans involve data parsing and analysis. Mentees would be responsible for understanding attacks in the datasets we are working with, parsing the data to construct streams on which machine learning and statistical analysis algorithms can be run, and analyzing the data and presenting the results. If a project yields positive results, I plan on working with the mentee towards publication.

Possible types of exploration:
- Exploring the efficacy of different methods of converting semistructured monitor data (e.g., system logs) into data streams on which learning algorithms can be run
- Analysis of security monitor data to see how data sources are dependent on one another, and how this might impact the results of intrusion detection algorithms, especially when systems are under attack
- Data-driven attack hypothesis generation and testing using statistical analysis and evidential reasoning

Desired Coursework/Experience:
Python programming ability is highly desired, though a quick study with proficiency in another language (C++, Java, etc.) and a desire to learn Python would also be welcome. The mentee will be expected to use Python data parsing and analysis tools and libraries, so prior experience with tools like PyParsing, Numpy/Scipy, and Pandas would be nice but not required. Mentee would be expected to devote at least 5 hours/week to the project, with more being desirable.

Ideal candidate will have proficiency in basic probability theory and some knowledge of random processes (ECE 313 or CS/STAT 361). Background in machine learning (CS 412, CS 446, or similar) would also be desirable but not required. I can teach you all of the required mathematics.

Since the work will be geared towards publication, students looking to complete an undergraduate thesis and/or apply to grad school in the future would be highly desired. In such a case, I would also involve the student in the research paper writing process (this might require a commitment longer than one semester based on submission deadlines).

Additional Questions for Applicant
What is your goal in participating in this program, and what do you hope to get out of it?
What is your background and interest in data science and security?
If you find the work interesting, would you be interested in continuing in subsequent semesters/years?
In the age of ever-increasing information complexity, the need to efficiently evaluate computation in a distributed environment is quickly becoming an important problem. I am currently developing a distributed system that targets at high-performance distributed computing. The goal is to simplify the process of writing a distributed program. Users write sequential programs and need have NO understanding of details (or hassles) behind. The system automatically distributes the computation and hides many details such as fault tolerance and message passing from users.

Possible Projects:

a. Research an efficient polling strategy for event-driven programming.

b. Research a testing flow for asynchronous event environment.

c. Front-end GUI design.

d. Develop software libraries (e.g., machine learning, graph, etc.) on top of the system.

Please be noticed that all projects will be very CODING-INTENSIVE. Regular meeting for code review and check-in is required.

Desired Coursework/Experience:

Good understanding of (or strong interests in) C/C++, POSIX, network socket, functional programming, and Linux system programming. Experience in modern C++ (by modern we mean at least C++11) is a strong plus.

Additional Questions for Applicant

“Are you self-motivated?”

“Do you like system programming?”

“Can you work together or collaborate with a team?”

Mentor Note: The last question is the most important to me.
My research focuses on nano-engineering graphene and 2-dimensional materials based nanostructures and devices for multifunctionality:

i) Investigating mechanically-driven nano-manufacturing of graphene and two-dimensional materials for multifunctionality

ii) Understanding surface characteristics of graphene and 2D materials

iii) Developing multifunctional mechanical meta-materials and sensor devices

In the different words, I work with the most promising “wonder material” in the world. Graphene, a two-dimensional carbon allotrope, has received immense scientific and technological interest since its discovery. Graphene’s combination of exceptional mechanical properties, superior carrier mobility, high thermal conductivity, hydrophobicity and potentially low manufacturing cost has signified itself as a superior base material for next generation bioelectrical, electromechanical, optoelectronic, and thermal management applications.

Every day, I design interesting experiments to discover future applications or answer fundamental questions concerning my material of choice. In the past, I sought to cut down on the unnecessarily complex (and expensive) infrastructure requirements on device fabrication by adopting tabletop commercial products.

Possible Projects:

I have a few projects under my belt currently which I would appreciate new perspectives:

i) Gas separation and water desalination by graphene foam /CNT membranes. One can only imagine the implication of this technology. The good thing is that my preliminary studies thus far is favorable. A definable role in my project for you would be to synthesize these membranes and testing it in real-time.

ii) Graphene kirigami devices. I am interested in exploiting “systematic voids” within the substrates to achieve greater stretchability and sensitivity in comparison to conventional graphene devices. The executable tasks hereby would be to use explore technique/tool such as photolithography or even silhouette cutting.

Desired Coursework/Experience:

Frankly, there isn’t much prerequisites required to carry out these projects as one can definitely acquire the necessary skills/techniques with time. However, I do appreciate someone with strong discovery aptitude. If so, you will have a very rewarding experience in Nam Research Group.

Additional Questions for Applicant

i) Are you comfortable with a certain level of independent work? This is very much like cooking. I will demonstrate first and hand you the recipe then. Soon after, you start tinkering around on your own.

ii) Can you spare at least 4-6 hours a week to push these projects forward? Experimental works require dedication of time and efforts. In this matter, you reap what you sow.
I am a graduate researcher in safety group under RAILTEC. The main purpose of our researches is to understand the possible risks involved in railroad transportation and to develop statistical methods to analyze risks associated with certain types of railroad transportation. My background is in tank car release analysis, which estimates the possibility of hazardous material release on a given route with a given tank car type.

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<th>Possible Projects:</th>
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<tr>
<td>Getting traffic data from time table.</td>
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<td>Summarizing accidents causes.</td>
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<td>Organizing accident database.</td>
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<tr>
<td>Literature review on new technology to improve railroad safety.</td>
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<td>And so much more when school starts...</td>
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<th>Desired Coursework/Experience:</th>
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<td>Mentees can join our weekly safety group meeting to see what projects are currently going on. Knowing Excel is a good idea.</td>
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<th>Additional Questions for Applicant</th>
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<td>Are you interested in learning statistical analysis?</td>
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Jamie Clark

I am a 2nd-year graduate student in the construction materials program under The Department of Civil and Environmental Engineering. My research interests include cement hydration mechanisms, early age properties of concrete, and alternative cementitious materials. Currently, I am exploring the use of X-ray computed tomography (X-ray CT) as a characterization technique for cement paste microstructure. X-ray CT offers advantages over existing characterization techniques (i.e. SEM, TEM, MIP) because it is non-invasive, non-destructive, and produces two-dimensional images as well as three-dimensional reconstructions allowing for a more realistic look at the microstructural properties of hydrated cement. The ability of X-ray CT to overcome limitations of current characterization techniques could have a transformative effect on the way that Portland cement is designed for use in industry.

Possible Projects:
Mentees would use X-ray computed tomography (X-ray CT) to explore foam cement, a low strength construction material containing a honeycomb-like network of pores. Due to its pore structure, concrete made with foam cement has the ability to absorb energy better than traditional concrete. Its low density also makes it ideal for temporary construction needs as it can be placed and removed in a short time frame. The goal of this project is to quantify and characterize the three-dimensional pore network of foam cement and correlate the results to rheological and mechanical properties. Students will get the unique opportunity to observe and learn about X-ray CT experiments performed in the state-of-the-art microscopy suite at The Beckman Institute for Advanced Science and Technology, get hands on experience in image analysis and data processing, and gain knowledge about the properties of fresh and hardened cement paste.

Desired Coursework/Experience:
Students should have a basic knowledge of cementitious materials. Prerequisite: CEE 300 - Behavior of Materials

Additional Questions for Applicant

Question 1: What are you hoping to gain from participating in PURE?

Question 2: What are some of your academic or professional interests?

Question 3: How would you describe your learning style?
The wind engineering group at the University of Illinois at Urbana Champaign is a relatively new group advised by Prof. Frank Lombardo. The main research areas of the group are extreme wind characterization, bluff body aerodynamics, wind engineering, structural damage and reliability, natural and multi-hazard analysis and wind energy. The goal of the group is to reduce windstorm losses through understanding windstorms and their impacts by bridging the gap between the physical sciences and engineering practice.

We are currently working to refine structural fragility curves based on tornado damage surveys, improve numerical models relating wind pressures on a structure to the wind's angle of attack, and the design and commissioning of new wind engineering research field laboratory.

Possible Projects:

Wind tunnel refurbishing

An existing wind tunnel at University of Illinois at Urbana Champaign that was unused for several years will be refurbished to be used as a research facility for the wind engineering group. The undergraduate students will collaborate with the wind engineering group and technical staff to assemble, instrument, test and repair (if necessary) all the components of the wind tunnel.

Undergraduate researchers will be given the opportunity to focus on a specific component of wind tunnel commissioning (such as the design of roughness elements to model the atmospheric boundary layer or configuration of the hardware/software needed for data collection).

Desired Coursework/Experience:

The student should be highly motivated and team work skills are extremely important. Specific knowledge of wind engineering and/or fluid dynamics would be helpful but is not necessary.

The wind tunnel refurbishing will be at Rantoul, IL (25 min drive from campus).

Additional Questions for Applicant

Why are you interested in collaborating in this project?
What do you expect to get from this project?
What do you know about wind engineering?
My research interests lie in the field of structural analysis and understanding the effects of forces on structural elements. I have been a part of researches involving various software like STAADPro, PLAXIS3D and WaterGems. Knowing how to use the software and understanding the calculations and tools that the software utilizes to solve a particular problem are two very important parts of model generation and subsequent solution finding in Civil Engineering. To achieve this understanding, a good grip on structural analysis of various kinds of buildings is very important.

Possible Projects:

I encourage the students to come up with a project idea of their own, in an area related to structural analysis (could even be a software based project idea)

Pick a building in campus and analyze the forces through the building. This would involve tracing out the basic structural design of the building, determining the dead load (through calculations), making appropriate assumptions for live load and calculating wind load. As a result of this project, the forces at the foundation of the building could be found. Additionally, these results could be compared with those obtained in the model simulated on STAADPro.

Study STAADPro and determine its limitations and pitch an idea for how to improve the software to eliminate those shortcomings.

Desired Coursework/Experience:

Basic knowledge of the free body diagrams and flow of forces.

Candidate should have the STAADPro software loaded in their PC

4-5 hours of work per week and weekly meetings.

Additional Questions for Applicant

What do you look to gain from this experience?
What project are you interested in? Why?
Have you worked on a similar topic before?
I am a second year MS student in Environmental Engineering. In short, my research focuses on nitrogen cycling in agricultural ecosystems. My current project has two main components: field work and modeling. Through field work I collect air and water samples from farm fields to analyze for nitrous oxide and nitrate, respectively. I am then able to determine how nitrogen losses of various agricultural systems differ based on different management strategies. I also model nitrogen losses through the Denitrification-Decomposition model to be compared with field measurements for model evaluation.

Possible Projects:

The main focus of the project would be modeling nitrous oxide emissions in the Denitrification-Decomposition model. The student will be assigned various preselected research articles on measured nitrous oxide emissions from agricultural sites in the United States. The student will be responsible for identifying necessary input parameters within the article, obtaining missing data from online databases, creating model input files, running the model, and visualizing model output. They will compare model output to measurement data to evaluate model performance. They will also make conclusions based on model output about the influence of different farm field management practices on nitrogen losses. In addition, if the student is available during periodic field sampling periods, they would assist in collecting gas samples from field chambers.

Desired Coursework/Experience:

Requirements:
- access to a computer (PC only)
- basic understanding of Microsoft Excel
- interest in computer modeling
- ability to work independently

Optional:
- willingness to assist with occasional field work
- familiarity with programming and/or computer modeling

Additional Questions for Applicant

If you are interested in working on this project, please email your resume/CV to mfoltz2@illinois.edu with the subject line PURE_{your name}. Material Sciences and Engineering
I use scanning transmission electron microscopy and spectroscopy to understand nanomaterials and devices at the atomic scale. I aim to image the structure, bonding, electronic, and optical properties of materials (especially 2D materials such as graphene) with exceptional precision utilizing recent advances in aberration-corrected electron microscopy. Overall, my research aims to apply insights of atom-by-atom microscopy to design novel nanomaterials and devices.

Possible Projects:

1) This project entails optimization of graphene exfoliation techniques to achieve high-density monolayer flakes on Si wafer. Once successful exfoliation is achieved we will move to learning transfer techniques to get graphene flakes on TEM grids for imaging/analysis.

2) This project is a graphene growth excursion. We need best recipe (utilizing facilities on campus) to grow large monolayer regions for a variety of imaging experiments. Once again, after we consistently grow high quality graphene we will move to transfer techniques for imaging/analysis.

Desired Coursework/Experience:

Looking for an interested and excited individual who is ready to learn and can commit ~5hrs a week. No particular coursework is required but some previous laboratory experience is appreciated.

Additional Questions for Applicant

Why are you interested in doing research?

What is your goal of participating in this program/what do you hope to get out of it?

What is your major, or what do you plan on majoring in?
### Avesta Hojjati

My research interest lies in the intersection of security and privacy. More specifically, I work on embedded devices and identify their security vulnerabilities. Additionally, I propose and design defensive measurements for such devices.

**Possible Projects:**
- Security in medical device (attack and defense), Security for manufacturing floor (attacking machinery)

**Desired Coursework/Experience:**
- Passion for security & privacy and enthusiastic about research, familiarity with one programming language and Linux.

**Additional Questions for Applicant:**
1. What's your perception of research?
2. What's your ultimate goal of conducting research?
3. Will you be interested in long term collaboration?
4. Do you consider graduate school?

### Mohammad Hosseini

I'm Mohammad, a 4rd-year PhD student in Computer Science in the Systems & Networking group. Mobile and wearable systems, healthcare, and multimedia systems are my main areas. I'm interested in any research topic targeting mobile and wearable devices (e.g. Energy-Efficiency, Adaptations, Protocols, etc.), healthcare systems (e.g. telemedicine, mobile healthcare, etc.) as well as multimedia systems, including games, Videos, and virtual reality.

**Possible Projects:**
- It is a real-world and high-impact project, which includes profiling of cellular network coverage in routes between two cities (Hoopeston to Champaign). The whole project combines mobile application development and software engineering, and developing algorithms, data engineering, and real test-bed analysis if we have time.
- The main task assigned to the mentees will be to develop a mobile app to log and profile cellular coverage (3G, 4G) on a smartphone. We might need to drive through the two cities to collect coverage data. Optionally, we might extend the problem and mathematically model the problem for further analysis.

**Desired Coursework/Experience:**
- Experiences in Android or IOS development is required.
- Driving between the cities requires a car!
- being in ECE would be a plus

**Additional Questions for Applicant**
- What is your major (ECE or CS) and what year? (e.g. ECE, 1 or CS, 2)
- Do you have experiences in mobile app development? (Android, IOS, etc.)
- Are you willing to drive and log 50 miles between two cities?
I work on security and privacy, specifically privacy-preserving systems. Currently, my research focuses on two separate problems: secure outsourcing of cloud storage and computation, and privacy-preserving data publishing. Secure outsourcing of cloud storage and computation is about using cryptographic techniques to provide data security and privacy when entrusting sensitive data to cloud services. In particular, my work aims to build practical systems by combining well-established cryptographic techniques and system-level insights.

Possible Projects:
I have projects available on data privacy topics.
Keywords: data privacy; differential privacy; machine learning and privacy.
Note: projects on cryptography or any security and privacy related topics are also available for mentees with the necessary background.

Desired Coursework/Experience:
basic knowledge of probability and statistics
(some) experience with MATLAB, R, scipy, or similar
(Familiarity with machine learning concepts and tools is definitely a plus but is not required.)

Additional Questions for Applicant
Why do you want to do research? (Why now?)
Do you have some research experience or relevant skills / knowledge?
My research spans the dually mathematically and philosophically rigorous subtopic of ‘learning how to learn’ in machine learning to the deployment of a robotic gaming system. Research with the theory subtopic will focus on extending our research in learning to predictively prioritize sensing to the consensus problem domain. The robotic gaming system, in addition to being a key part of our educational outreach, is an experimental robotic system which uses the open source Robot Operating System. Research projects with the robotic gaming systems will range from human-robotic interaction studies to the development and integration of new interactive robotic technologies into the robotic gaming system.

Possible Projects:

Theory track

The student will learn about the EIEIO algorithm and the consensus problem. The goal is to apply the EIEIO algorithm to the consensus problem to ascertain whether agents in a network can learn to predict their most informative neighbors and consequently reach consensus faster than conventional approaches. Hence, the student will be tasked with applying the EIEIO to the consensus problem and will have the opportunity to write a paper on the results as a first author for the Conference on Decision and Control.

Robotics track

Option A: Human-Robot Interaction Study

Interested students will survey, with guidance, human-robot interaction studies and design a human-robot interaction study to examine how existing versions of the robotic gaming system affect middle school aged students’ perception of robotics and related STEM fields. The student will also have the opportunity to write a paper on the results as a first author for the International Conference on Human-Robot Interaction.

Option B: ROS-Compatible Augmented Reality

Interested students will learn how to use the Robot Operating System (ROS), and how ROS is used in the robotic gaming system. The student will design and implement a ROS-compatible communication system such that augmented reality interaction between robots is enabled and will have the opportunity to write a paper on the technology for the International Conference Human-Robot Interaction.

Desired Coursework/Experience:

Theory Track

Calculus 1-3, Introduction to Statistics and MATLAB.

Robotics Track

Option A: Human-Robot Interaction Study

Introduction to Statistics and Python Programming Experience.

Option B: ROS-Compatible Augmented Reality

C++ Programming Experience

Additional Questions for Applicant

What are some ways that you will demonstrate initiative as a mentee in the mentee-mentor relationship?

What role(s), such as entrepreneur, office worker, teacher, etc., do you want your future career to include and why?

What, if any, team communication software have you used in the past?
Andrew Louis

I am a second year computer science MS student in the Real-Time and Embedded System Lab. My research is centered on unmanned aircraft. Specifically, I have been developing an emulation environment to allow for development of autopilots. Using this emulation environment, I developed an autopilot that we actively test on a real UAV. Additionally I have been working on creating a graphical user interface for controlling and monitoring the UAVs in flight.

Possible Projects:

Graphical User Interface for Real-Time Flight Monitoring and Control of UAVs
Develop and integrate additional components into the graphical user interface (GUI) used to monitor and control unmanned aircraft in flight.

Fixed-Wing (Airplane) Autopilot Expansion
Implement new flight modules into an existing autopilot to support advanced maneuvers such as landing and aerobatics (stunts)

Desired Coursework/Experience:

For GUI:
Familiarity with C++ and Qt

For Airplane Autopilot Expansion:
Familiarity with C and background knowledge in linear algebra.

Additional Questions for Applicant

Please send me an email with title PURE-FALL-2016-<Your Name>. Attach your resume, describe your past project experiences and state what you would like to work on and why.
We are working on solving the Global Cooking Problem by developing portable, stored solar cookstoves. Air pollution from burning solid fuels for cooking (wood fires, for instance) contributes to both health problems and climate change. Our technology uses the sun’s energy to allow people to cook at temperatures close to fire and, because it can store this energy, people can cook where and when they would like.
Or Dantsker

I am a first year aerospace engineering PhD student in the Real-Time and Embedded System Lab. My research is focused on unmanned aircraft integration and flight testing. I am particularly interested in improving in-flight data acquisition methods and do so using a variety of unmanned platforms - airplanes and helicopters.

Possible Projects:

Helicopter Autopilot

Implement a helicopter autopilot using an established control scheme and test it in an emulation environment and/or on a real unmanned helicopter.

Stereo Vision Based Target Tracking for UAV Landing

Develop a vision algorithm to take real time imagery from 2 wing-mounted, downward-looking cameras to estimate the relative position of the aircraft to a ground-based, moving landing platform. The algorithm will be tested on a real unmanned aircraft.

Desired Coursework/Experience:

Heli AP:
Familiarity with C and background knowledge in linear algebra.

Stereo Vision Landing:
Familiarity with computer vision.

Additional Questions for Applicant

Please send me an email with title PURE-FALL-2016-<Your Name>. Attach your resume, describe your past project experiences and state what you would like to work on and why.

Bioengineering

Alex Cerjanic and Giang Chau Ngo

Possible Projects:

While we have had success with the initial release of our PowerGrid software, we have a number of outstanding tasks to improve the usability and impact of the tool on our and other research groups. There are two main thrusts where PURE mentees can make a measurable impact:

i) We would like to add unit tests to our software so that we can use continuous integration to ensure numerical accuracy and correct functionality as we continue to develop the core algorithms and make improvement.

ii) There is an effort in our field to standardize file IO from clinical and preclinical scanners to reconstruction software using an open-source vendor independent format. We would like to integrate this library (ISMRMRD http://ismrmd.github.io) as an input output format in our PowerGrid package.
Alex Cerjanic:

My research involves the use of Magnetic Resonance Imaging (MRI) to quantify the state of microvascular blood flow in the brain. With my advisor, Brad Sutton in Bioengineering, we are interested in the quantitative state of the microvascular architecture as it undergoes changes and degeneration with age. As MRI is a fairly low sensitivity technique, we use advanced acquisition and reconstruction techniques to maximize the sensitivity of the MR imaging process. These advanced reconstruction techniques do improve the sensitivity and signal to noise ratio of the acquired MR images, but at a cost of significant computation. As part of this work, we have sped up the process by developing open source GPU-accelerated and HPC enabled reconstruction software called PowerGrid (http://mrfil.github.io/PowerGrid).

Giang Chau Ngo:

Desired Coursework/Experience:

To approach this project successfully, undergraduate students will need to be proficient in C/C++, be fairly comfortable using Git to manage source code, and be comfortable building source code at the command line in Linux. Experience with CMake will also be very helpful. For subproject #1 familiarity with Unit Testing is beneficial, however, in the absence of this, a strong desire and motivation to learn about unit tests will be sufficient. For subproject #2: undergraduate students will need experience in approaching new and unfamiliar APIs, reading documentation, and using and implementing functionality from the new APIs.

It is our expectation that students primarily in CS will likely be a good fit for this project. Students will be expected to commit 5-10 hours per week (average) on this project, including meeting for one hour per week as a team.

Additional Questions for Applicant

i) What kind of software-related projects have you worked on in the past? This may include research projects, open source projects, projects for fun, or class projects.

ii) How comfortable are you with building software at the command line and/or using makefiles?
My research uses model-based iterative reconstruction to improve functional Magnetic Resonance Imaging (fMRI). fMRI is a popular, non-invasive technique to track dynamic brain activation while subjects are able to perform cognitive or simple motor tasks. The information gained has led neuroscientists to deeper understanding of the relationships between brain structure and function. While fMRI is a powerful and versatile technique, it suffers from fairly low spatial and temporal resolution as it is usually implemented. My research uses computation to better model the activation signal via R2* mapping or to improve the temporal resolution of fMRI via low-rank models. Each of these techniques demands significant computation to implement, which drives my interest in using GPUs and HPC clusters and supercomputers to accelerate our problems.

Neuroscience

Manoj Kumar

Possible Projects:
Implement a deep neural “scene” network on pictorial stimuli consisting of typical and atypical examples of various categories. This will help us understand what layers of a deep network discriminate between typical and atypical exemplars.

Implement a toolbox for representational similarity analysis (RSA) to measure semantic distances across categories using fMRI signal and compare it to distances in semantic feature space.

Apply machine learning algorithms to EEG data and build a classifier to determine similarities between the EEG signal for verbal and pictorial stimuli.

Desired Coursework/Experience:
An interest in understanding the human brain and using Machine Learning.

Programming proficiency in one or more of MATLAB/Python/R.

Additional Questions for Applicant
None
Broadly, my research focuses on how is our knowledge system represented in the brain and how does it interact with our visual system. A long-standing core question that has remained unanswered in cognitive science is: Do different modalities (pictures, words, sounds, smells, tastes and touch) access a common store of semantic information? I study this question using pictures of natural scenes, pictures of objects and also words that describe scenes and objects. Using machine learning algorithms on functional Magnetic Resonance Imaging (fMRI) signals, we can determine if similarities exist for neuronal patterns of activity across pictures and words.

In addition to common semantic representations across pictures and words, I also study their dynamic interaction. Using electro-encephalograms (EEG), we examine processing of semantic and visual stimuli in real-time. While fMRI gives us high spatial resolution, we get high temporal resolution of neuronal activity using EEG. With this, we gain insights into the dynamic influence of semantics on visual processing.

More recently, the advent of deep neural networks has provided tools that help process information in multiple stages. This multi-stage approach is often thought to mimic the structure of brain function. I am looking to better understand if there are parallels between processing scene stimuli in the human brain and processing them via deep neural networks.

Possible Projects:

Use machine-learning techniques to analyze preprocessed (i.e. “ready-to-go”) EEG data. For example, you could help build a classifier to categorize segments of EEG data based on experimental condition, or to predict a continuous parameter about the stimulus. In the process, we would refine some scripts that would make formatting and preprocessing EEG data for that kind of analysis easier for other researchers at the lab (i.e. we would develop a pipeline). Compare different classifiers and interpret them – what do our results tell us about the relationship between the brain activity and the experimental stimulus?

EEG data contains a lot of useful information about brain activity, but before that can be analyzed, a lot of noise from other biological sources such as the eyes, muscles, and heart, needs to be tagged for correction or elimination. Build a classifier to tag where “artifacts” (junk data from eye movements, blinks, muscle activity, etc.) start and stop in the continuous EEG. Traditionally, simple thresholds are first applied to the raw EEG data and their general accuracy is confirmed by eye. This project would aim to reduce the need for human labor. By focusing on the continuous data, we would also make it such that artifact tagging would only need to be performed once prior to analysis. With our project, the data could be more easily broken up into segments of different lengths for different analyses, without needing to double check the artifact detection parameters each time. We would explore first applying Independent Component Analysis to the data, and then applying a machine learning algorithm (possibly a neural network) to predict which segments of data are contaminated, in an attempt to approximate human performance.
At the Cognition and Brain Lab, we study the cognitive and neural basis of language and memory function across the lifespan. As a mentee, you would have the opportunity to learn about multiple ongoing projects at the lab. Your primary mentor would be Cybelle Smith, whose research centers around how contextual cues, both verbal and in the environment, shape our understanding of language and meaningful images. Cybelle is interested in using machine learning techniques to conduct exploratory analyses on neural data, and to develop tools to further automate the research process. She uses electroencephalography (EEG; recording electrical ‘brainwaves’ at the scalp) to answer questions about the role of working and associative memory in language and picture comprehension.

Your brain produces inhibitory oscillatory activity called “alpha waves.” The phase of the alpha wave (whether it is suppressing or enhancing neural activity in the cortex at a particular point in time), may be related to when and how the brain processes semantic information about words. Learn about time-frequency analysis of EEG data. Help perform an analysis relating the phase of the alpha wave prior to seeing a word with the size and/or latency of a semantic processing effect that depends on how concrete or abstract the word is.

Help run participants for one of our experiments and learn how to collect and perform basic analysis on EEG data.

Help develop stimuli or experimental materials for an EEG experiment.

Desired Coursework/Experience:

Applicant must have programming experience (in any language). Some coursework in statistics or familiarity with basic concepts in statistics and/or data analysis is preferred. Although single semester students are welcome to apply, preference will be given to applicants who express interest in working with us for more than one semester.

In addition to the main project, mentee(s) would be encouraged to help out with smaller scripting / programming tasks, such as programming experiments, making scripts that generate lists of stimuli satisfying multiple constraints, etc. This could be a great way to learn about multiple research projects going on at the lab, and about considerations in experimental design, while helping out in a substantial way!

There are other opportunities to get more involved at the lab. We have (optional) weekly lab meetings and bi-weekly discussion groups on EEG methodology that you are welcome to attend.

Additional Questions for Applicant

1. What is your programming background? How comfortable are you with programming / scripting and what languages do you know?

2. What statistics courses have you taken, and how comfortable are you with data analysis? Describe any prior research experience.

3. What project(s) would you like to work on this semester, and what would you most like to take away from the experience? If you would be interested in staying on for more than one semester, please state that here.
Transition metal phosphide (TMP) catalysts are selective and active towards C-O bond rupture during oxygenate hydrodeoxygenation (HDO), however, the manner in which C-O bond rupture mechanisms and intrinsic barriers differ between transition metals and TMP are not well understood. In this project, the decomposition of oxygenates (e.g. formic acid and acetic acid) on pristine and P-modified Ru(0001) surfaces are compared using a combination of surface science methods. The findings will provide useful information for the rational design of TMP catalysts by enhancing C-O bond rupture, which will increase bio-mass conversion efficiency to platform chemicals.

Possible Projects:

The undergraduate student will have the opportunity to conduct supervised experiments along with an independent project to automating the molecular beam reactor using Labview software.

Desired Coursework/Experience:

Chemistry and organic chemistry experience, along with basic programming skills

Additional Questions for Applicant

Do you have any previous laboratory experience?

Why are you interested in chemical engineering research?