CS 598 EKS Spring 2024
Smart cities, homes, & beyond (Smart-X)

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Class Time:
Tuesdays and Thursdays
02:00 PM – 03:15 PM Central

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Course Assistants: Aryaman Dwivedi, Hanbo Guo, Prithvi Balaji

Course Website:
https://canvas.illinois.edu/courses/43496

Office Hours:
Mondays 4 – 5 PM
(and by appointment)

Course Description:

This course explores the principles and practice of smart physical places and things (Smart-X). New devices have been added to cities, homes, factories, cars, and even to humans (inside and out), hoping that this influx of technology will help us solve pressing societal issues in all facets of life, such as energy, personal health, environment, or safety. The challenges, however, remain in designing and scaling the hardware platforms, networking protocols, and sensing algorithms to enable this new class of computing. This course will cover state-of-the-art research papers that address various visions of the future platforms supporting Smart-X. It will also stress the cyber-physical aspects of these systems, providing safe, secure, and efficient interaction with the physical world. This course will offer significant hands-on experience through a semester-long project, paper critiques, lab sessions, and an overview of the commercial landscapes of the topics covered in class.

Pre-requisites

This class is open to Ph.D. and Master students as well as advanced undergraduate students. It would be helpful if you have taken a class in computer networks, embedded systems, or IoT, as the class materials will be easier to access. If you are not sure about the prerequisites, please contact the instructor.

Learning Goals of This Course:

At the end of this class, students should be able to:

1. Explain the basic operating principles and performance of the most-used technologies in mobile computing:
   - Sensing and Actuation
   - Networking protocols
   - Novel wireless technologies
   - WiFi-based sensing and localization
   - Radar-based sensing and imaging
2. Analyze a new wireless technology to extract key technical features and limitations.

- Specifically: infrastructure requirements, energy use, processing and timing demands, latency, and throughput.

3. Assess how the physical-world constraints of an application scenario map to the capabilities of wireless communication and sensing technologies.
   - Specifically: deployment area, device density, energy availability, spectrum access, and form factor.
4. Design a smart system and estimate its performance given an application scenario.
5. Review research papers and extract fatal flaws and research contributions.

Schedule:

Weeks	Tuesday		Thursday	
1	Jan-16	Getting Started	Jan-18	What makes things Smart?
2	Jan-23	Basics of embedded systems	Jan-25	Speed review
Smart things				
3	Jan-30	Smart phones, devices, wearable, objects & beyond	Feb-1	Intro to Signal Processing
4	Feb-6	Paper Critiques	Feb-8	Paper Critiques + lab lecture
5	Feb-13	Lab 1 - RPI Programming	Feb-15	Lab 2 - smart security cameras
Smart Buildings				
6	Feb-20	Smart Building: residential, commercial & beyond	Feb-22	Networks and Wireless
7	Feb-27	Paper Critiques	Feb-29	Paper Critiques + lab lecture
8	Mar-5	Lab 3 - Wireless Spying camera	Mar-7	Lab 4 - WiFi Sniffing
9	Mar-12	Spring Break	Mar-14	Spring Break
Smart Industries				
10	Mar-19	Smart Industry: manufacturing, retail, vehicle, & beyond	Mar-21	Sensing, Perception, Cognition
11	Mar-26	Midterm Project Presentation	Mar-28	Midterm Project Presentation
12	Apr-2	Paper Critiques	Apr-4	Paper Critiques + lab lecture
13	Apr-9	Lab 5 - Locating hidden cameras	Apr-11	Lab 6 - Localization Competition
Smart Cities				
14	Apr-16	Smart Cities, towns, streets, and beyond	Apr-18	Location, Location, Location!
15	Apr-23	Paper Critiques	Apr-25	wrap-up
16	Apr-30	Final project Demo	May-2	Final project Demo

participation:

We expect you to attend all lectures and lab sessions unless pressing and unforeseen conflicts arise. Conflicts that are persistent (e.g. registering for two classes with half an hour overlap) are not excused.

Class structure

Every three-week period will explore a particular smart-X. The first session of the three-week period will cover the application drivers and the commercial landscape of the topic. The second day of the three-week period will provide deep-dive overviews of underlying technologies in the form of a lecture. The second week of the three-week period will review research papers on that topic, and we will wrap up each smart-X with a lab week that offers in-class activities and hands-on experience through mini projects.

Lecture classes are for 75 mins, which will be roughly broken down into:

1. Lecture by instructor: 50 mins
2. In-class activities: 15 mins
3. Q & A and discussion: 10 mins

Grading Algorithm:

A quick reminder: Effective learning comes from active engagement and re-enforcement. Activities, assignments, and grading are designed to help with this.

25%	Paper review and discussion participation • Paper critiques before class: 20% • In-Class discussion participation: 5%
15%	Paper/Commercial Presentation

30%	Labs:
	• Lab activities make up one third of the work for this course. There are six total labs in this course.
	• Pre-labs are absolutely essential to your success during the lab session and will be graded as part of your lab checkpoint delivery.
	  ○ Post-lab report: 5% per lab (total of 3)
	  ○ Lab attendance and checkpoint delivery: 3% (total of 5 labs)

30%	Final Project • Proposal (1-2 pages): 5% • Progress report (4-5 pages): 10% • Final demo and report (6-7 pages): 15%

Final Grades

I believe in mastery learning. My goal is to teach you the material and for everyone to learn it. I am most successful if everyone in class *earns* an A. This class will not be curved.

A+ ≥ 100, A [95,100) A- [90,95), B+ [86.7,90), B [83.3,86.7), B- [80,83.3), C+ [76.7,80), C [73.3,76.7), C- [70,73.3), D [60,70), F [0,60).

Range notation [90,93) means 90 is included and 93 is not

Reading Assignments:

Each lecture session will have one or two reading assignments, which will be posted before the class. The students are expected to read the paper thoroughly and come to class ready to discuss them in detail. This is essential to get the most out of this class!

Before each class (11:59pm the night before the class), students must submit a short summary including the intellectual merit, strengths and weaknesses of the paper. No late reading submission is allowed. Each student may skip one review during the semester without affecting their grade.

Grading will be predominantly based on completeness (0-2)

- 0 not sufficient
- 1 okay, but not great
- 2 nailed it

Paper Presentation:

Every student will lead one discussion in the class and can choose between a commercial landscape presentation or a research paper presentation. In your research paper presentation, try to answer the following questions:

- What is the context of the paper?
- What is the problem addressed by the paper?
- How does it solve it?
- How does it evaluate that the solution is good?
- How is it an advance over prior art?
- How much impact has the paper had? Who cares?

In the commercial scan presentations, try to answer the following questions:

- What are major companies that supply products or services relevant to topic?
- How is the marketplace segmented?
- What is the business model?
- What are the major standards in this arena?
- Does commercial practice reveal important unaddressed research topics?
- Are there significant unmet need in this space?
- Why have these needs remained unmet?

A few pointers regarding student presentations:

- Sunday before your scheduled discussion: email a draft of your slides to the instructor (elahe@illinois.edu). This should be close to complete but does not need to be a final version.
- After your presentation, upload your final presentation slides to the canvas assignment. Only one team member needs to upload to Canvas, but they must add the other team members to the assignment
- A rough breakdown of points for paper presentations is as follows:
    - Basic structure and slide format (25 points) – flow of the presentation, use of pictures and animation, including discussion points throughout your presentation
    - Paper summary (25 points) – covering the key insights and ideas, easy to understand for non-experts, staying on time
    - Review Critiques (25 points) – identifying important intellectual merits, highlighting technical strength and weaknesses of the paper

    - Leading discussions (25 points) – engaging students by asking questions
- A rough breakdown of points for commercial landscape presentations are as follows:
    - Basic structure and slide format (25 points) – flow of the presentation, use of pictures and animation, including discussion points throughout your presentation
    - Key commercial factors (25 points) – covering marketplace segmentation, major companies, and business model
    - Review Critiques (25 points) – identifying important unaddressed research topics or unmet needs
    - Leading discussions (25 points) – engaging students by asking questions

Research Project:

The goal of the research project is to build your own smart-X, ideally connecting the topics in this class with your own research. Students can form teams of 3 to execute on projects.

The project checkpoints are as follows:

- Project Proposal Report: Feb 25
- Midterm review Presentation: March 26, 28
- Midterm report: March 31
- Final project demo: Apr 30, May 2
- Final project report/paper: May 11

Required Textbook:

There is no textbook for this course.

- For background and more depth in embedded system design and operation, we recommend Lee & Seshia's Introduction to Embedded Systems.
- For background in signal processing, we recommend "Signal Processing for Communications".
- stack overflow and electronics stack exchange are good debugging and lab resources support.
- For specific topics, additional resources are linked in the course slides.

Anti-racism and Inclusivity Statement

The intent of this section is to raise student and instructor awareness of the ongoing threat of bias and racism and of the need to take personal responsibility in creating an inclusive learning environment.

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students,

staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (https://bart.illinois.edu/). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.