CS 437 EKS Fall 2023
Topics in IoT: Wireless Sensing for IoT

Instructor:
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3108 Siebel Center for CS

Class Time and Location:
Tuesdays and Thursdays
2:00 PM – 03:15 PM Central
1214 Siebel Center for CS

Teaching Assistants: Ragini Gupta, Luke Jacobs, Daniel He

Course Website:
https://courses.grainger.illinois.edu/cs437eks/fa2023/CS437EKS.html

Office Hours:
by appointment

Course Description:

This course explores the foundations of smart wireless systems and wireless technologies for IoT through hands-on experimentation with real-world wireless devices. Students will perform bi-weekly projects in the IoT lab, building, analyzing, and evaluating WiFi-based (first half of the semester) and radar-based (second half of the semester) sensing solutions that are widely used in real-world applications (smart homes, IoT, self-driving cars, health monitoring, metaverse, and mixed reality systems). This course will offer significant hands-on experience through semester-long projects, lab sessions, and an overview of the commercial landscapes of the topics covered in class.

Pre-requisites

This class is open to undergraduate students only. It would be helpful if you have taken a class in computer networks, or embedded systems, as the class materials will be easier to access. If you are not sure about the prerequisites, please contact the instructor.
Keep in mind, this is an advanced course. Labs will have instructions of what you are supposed to do, but not step-by-step instructions of how you are supposed to do things. You are expected to use resources (Google, Stack Overflow, course staff, classmates, etc.) to figure out how to get things done.

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
   - Location and context awareness
   - 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.

Schedule:

Week	Date (Tuesday)	Day 1	Date (Thursday)	Day 2
1	08/22	Getting started	08/24	What makes things smart? Intro to embedded systems
2	08/29	Everything Smart! Smart phones, homes, & beyond	08/31	Basics of Signal Processing Intro to Sensing Modalities
3	09/05	Lab 1-2 Raspberry-Pi Programming	09/07	Lab 1-2 Build a Smart Security Camera
	WiFi As a Sensor			
4	09/12	Wireless Networks	09/14	Basics of Radios
5	09/19	Lab 2-1 From Smart to Spying Cameras	09/21	Lab 2-2 Detecting Hidden Spying Cameras
6	09/26	Wireless Localization	09/28	Wireless Sensing
7	10/03	Lab 3-1 Localize Hidden Spying Cameras	10/05	Lab 3-2 Build your Super SpyCam Finder
8	10/10	Zero-power Platforms	10/12	Hot Topics in WiFi Sensing
9	10/17	Midterm Project Competition	10/19	Midterm Project Competition
	Radar Sensing			
10	10/24	Intro to Radars and Applications	10/26	FMCW Radar Sensing
11	10/31	Lab 4-1 Radar-based motion detection	11/02	Lab 4-2 Keep your distance with radars!
12	11/07	Radar Doppler/Phase processing	11/09	Hot Topics in Radar Sensing
13	11/14	Lab 5-1: Radar-based human sensing	11/16	Lab 5-2: Talk with a radar!
14	11/21	Fall Break	11/23	Fall Break
15	11/28	Commercial Landscape of Smart Wireless Systems	11/30	Future of Wireless IoT!
16	12/05	Final Project Demo	12/07	Final Project Demo

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.

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

We will be alternating lecture and lab sessions every other week. The lecture sessions will be held in the classroom, while lab sessions will be held in the IoT lab at Siebel 1109.

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

1. Lecture by instructor: 50 mins
2. Q & A and discussion: 10 mins
3. Quiz: 15 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.

50%	Labs:
	• Lab activities make up the bulk of the work for this course. There are five total labs in this course.
	• Pre-labs are absolutely essential to your success during the lab session, which are due by the start of the lab. No exceptions or late policies for pre-labs.
	• 10% each lab:
	  ○ Pre-lab submission: 2%
	  ○ Lab attendance: 2%
	  ○ Post lab report: 6%

10%	Quizzes: • lectures start with a mini-quiz. These will be (very) short and will cover materials from the prior lecture. (1%/ea, total of 10 Quizzes).
20%	Midterm Project (Build a Spy Wireless Camera Finder) • Proposal (1-2 pages): 5% • competition demo: 5% • Final report/script (3-4 pages): 10%
20%	Final Project (Build your radar sensing system) • Proposal (1-2 pages): 5% • Final report (3-4 pages): 5% • Final demo/presentation: 10%

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+ >96.7, A [93,96.7), A- [90,93), 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

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.