CMSC 491/691: Mobile and Wireless Sensing

Syllabus

Fall 2024

Instructor: Dong Li

Time: Tuesday & Thursday 09:00 AM – 10:15 AM

Location: Interdisciplinary Life Sciences Building (ILSB) 237

Office Hours: Tuesdays from 2:30 PM to 3:30 PM at ITE 355 or by appointment via email

Course Website: https://leetton.github.io/teaching/CMSC691Fall2024/

Course Overview

The rapid expansion of mobile and wireless technologies, alongside breakthroughs in deep learning, has led to the emergence of the "Artificial Intelligence of Things" (AIoT). In this cutting-edge paradigm, wireless signals do more than just facilitate communication between devices—they also enable interaction with people and the physical environment. This course provides an in-depth exploration of key concepts in mobile and wireless sensing, including the fundamentals of wireless signals, signal processing techniques, and machine learning algorithms.

The course is structured into six comprehensive modules, each focused on a specific application domain, such as *localization and tracking, gesture and activity recognition, health sensing, material and environmental sensing, multi-modal sensing, and privacy-preserving sensing*. Throughout the course, students will engage with recent research papers that highlight innovative designs, algorithms, and applications within the field of mobile and wireless sensing.

A significant component of the course involves a semester-long, research-oriented project where students will gain hands-on experience by designing and building their own AIoT systems. This project will allow students to apply theoretical knowledge to practical challenges, fostering a deeper understanding of the AIoT landscape.

Communication

I encourage all students to actively participate in classroom discussions, whether by asking questions or sharing your perspectives. Your feedback throughout the semester is valuable to me, and I welcome it as we progress through the course.

- Course announcements, materials, and assignment submissions will be managed through Blackboard.
- For general inquiries or assistance, please use the Blackboard discussion board or email. When emailing, please include the following prefix in the subject line: *[CMSC 491/691 Mobile & Wireless Sensing] <your subject>*.
- Response time for emails is typically within 24 hours on weekdays.

Reading Materials

The class does not require a mandatory textbook. However, if you wish to deepen your understanding of mobile and wireless sensing, I recommend reading papers from conferences such as MobiCom, MobiSys, SenSys, IPSN, PerCom, IMWUT, and others.

Grading

- Paper Review: 16%
- Paper Presentation: 24%
- Research Project: 60%
    - 10% for project proposal presentation & report
    - 10% for project milestone presentation & report
    - 20% for final presentation & demonstration
    - 20% for final report

Paper Reviews

- You will review and discuss 16 assigned research papers. Those papers can be downloaded from either course website or Blackboard. Please follow these guidelines when writing your review:
    - Summary: Briefly summarize the key points of the paper.
    - Strength: Identify and discuss the strengths of the paper.
    - Weakness: Critique the paper by addressing any limitations or areas that could have been improved.
- **Deadlines:** You are expected to read papers and submit reviews via *Blackboard* by **11:59 PM** the night before the lecture (i.e., Monday for a Tuesday lecture and Wednesday for a Thursday lecture).
- **Late Submission:** No late submissions allowed.

Paper Presentation

- Each student will be responsible for presenting a paper during the course. You can choose one paper from one of the six modules to present. Keep the following questions in mind to help you structure your presentation:
  - Motivation: What problem is the paper solving and why is it important?
  - Methodologies: What is the main idea of the paper?
  - Novelty: How does the paper differ from previous work?
  - Future Work: Are there any flaws in the paper? How would you improve the paper or build on it in future work?
- **Deadlines:** You are expected to submit your slides via *Blackboard* by **11:59 PM** the night before your presentation.
- **Late Submission:** No late submissions allowed.

Research Project

- The research project is a core component of the course and will be conducted in groups of 2 or 3 students. You will propose, design, and execute a project that aligns with the course topics. It is acceptable—and often beneficial—to work on a class project that complements your ongoing research. If you're unsure whether your research topic would be appropriate, please discuss it with Dong.
- **Deadlines:** The project milestones and rough timeline are as follows.
  - Proposal Report (1-2 pages): Due by 11:59 PM on October 2
  - Milestone Report (3-4 pages): Due by 11:59 PM on November 4
  - Final Report (7-8 pages): Due by 11:59 PM on December 17
- **Late Submission:** 10% deducted for each late for **all group members**.

CMSC 491 vs. CMSC 691

The lectures and class materials are identical for both the undergraduate-level course (CMSC 491) and the graduate-level course (CMSC 691). However, the primary distinction lies in the scope and expectations of the projects. Graduate students are expected to develop a project centered around an original and unique research hypothesis with the potential for publication. Undergraduate students are also encouraged to propose original and unique research hypotheses but may alternatively choose to work on an idea provided by the instructors.

Course Schedule

The class schedule is tentative and subject to change.

#	Date	Topic	Assigned Paper
1	Thu, Aug 29, 2024	Course Introduction and Overview	
		Module 1: Localization and Tracking	
2	Tue, Sep 03, 2024	Localization and Tracking: WiFi	Experience: Pushing Indoor Localization from Laboratory to the Wild
3	Thu, Sep 05, 2024	Localization and Tracking: RFID	Drone Relays for Battery-Free Networks
4	Tue, Sep 10, 2024	Localization and Tracking: Acoustics	FM-Track: Pushing the Limits of Contactless Multi-target Tracking using Acoustic Signals
5	Thu, Sep 12, 2024	Student Presentation	TBD
		Module 2: Gesture and Activity Recognition	
6	Tue, Sep 17, 2024	Gesture and Activity Recognition: mmWave	Soli: Ubiquitous Gesture Sensing with Millimeter Wave Radar
7	Thu, Sep 19, 2024	Gesture and Activity Recognition: LTE	Robust Dynamic Hand Gesture Interaction using LTE Terminals
8	Tue, Sep 24, 2024	Gesture and Activity Recognition: Ambient Light	Self-Powered Gesture Recognition with Ambient Light
9	Thu, Sep 26, 2024	Student Presentation	TBD
		Module 3: Health Sensing	
10	Tue, Oct 01, 2024	Health Sensing: Vital Sign Monitoring	Your Smart Speaker Can "Hear" Your Heartbeat!
11	Thu, Oct 03, 2024	Project Proposal Presentation and Discussion	
12	Tue, Oct 08, 2024	Health Sensing: Sleep Stage Monitoring	WiFi-Sleep: sleep stage monitoring using commodity Wi-Fi devices
13	Thu, Oct 10, 2024	Student Presentation	TBD
		Module 4: Material and Environment Sensing	
14	Tue, Oct 15, 2024	Material and Environment Sensing: Food and Liquids	Liquid Testing with Your Smartphone
15	Thu, Oct 17, 2024	Material and Environment Sensing: Soil	SoilCares: Towards Low-cost Soil Macronutrient and Moisture Monitoring Using RF-VNIR Sensing
16	Tue, Oct 22, 2024	Material and Environment Sensing: Temperature	VECTOR: Velocity Based Temperature-field Monitoring with Distributed Acoustic Devices
17	Thu, Oct 24, 2024	Student Presentation	TBD
		Module 5: Multi-modal Sensing	
18	Tue, Oct 29, 2024	Multi-modal Sensing: WiFi + Camera	Through-Wall Human Pose Estimation Using Radio Signals
19	Thu, Oct 31, 2024	Multi-modal Sensing: Audio + Ultrasound	Sensing to Hear: Speech Enhancement for Mobile Devices Using Acoustic Signals
20	Tue, Nov 05, 2024	Project Milestone Presentation and Discussion	
21	Thu, Nov 07, 2024	Multi-modal Sensing: mmWave + Depth Camera + IMU	Cosmo: Contrastive Fusion Learning with Small Data for Multimodal Human Activity Recognition
22	Tue, Nov 12, 2024	Student Presentation	TBD
		Module 6: Privacy-preserving Sensing	
23	Thu, Nov 14, 2024	Privacy-preserving Sensing: Signal-level Methods	You Can Hear But You Cannot Record: Privacy Protection by Jamming Audio Recording
24	Tue, Nov 19, 2024	Privacy-preserving Sensing: Algorithm-level Methods	ClusterFL: a similarity-aware federated learning system for human activity recognition
25	Thu, Nov 21, 2024	Student Presentation	TBD
		Project Presentation and Demonstration	
26	Tue, Nov 26, 2024	Project Presentation and Demonstration I	
	Thu, Nov 28, 2024	No Class - ThanksGiving	
27	Tue, Dec 03, 2024	Project Presentation and Demonstration II	
28	Thu, Dec 05, 2024	Project Presentation and Demonstration III	
29	Tue, Dec 10, 2024	Project Presentation and Demonstration IV	

Class Policies

- **Academic Integrity**

  Plagiarism or any form of cheating is not tolerated in this class. All submitted work must be your own. If you are suspected of cheating, plagiarism, or other forms of academic dishonesty, your case will be referred to the Undergraduate Academic Conduct Committee or the Graduate Council Grievance Committee, and this may result in lost credit, course failure, suspension, or dismissal from UMBC, depending on the Committee's decision. For more information on what constitutes academic dishonesty, please consult UMBC Academic Conduct. If you are struggling with the class content in any way, it is your responsibility to communicate with the instructor so that he can assist you.

- **Generative AI Tools**

  It is not allowed to use any generative AI tools, including but not limited to language models such as ChatGPT, to complete any part of assignments in this class. Any violation of this rule will be considered cheating.

- **Collaboration Policy**

  You are only allowed to work in groups on the research project. When submitting the report, you must clearly indicate the names of all group members and specify each person's contributions to the assignment.

UMBC School Policies

- **Accessibility and Disability Accommodations, Guidance and Resources**

Accommodations for students with disabilities are provided for all students with a qualified disability under the Americans with Disabilities Act (ADA & ADAAA) and Section 504 of the Rehabilitation Act who request and are eligible for accommodations. The Office of Student Disability Services (SDS) is the UMBC department designated to coordinate accommodations that creates equal access for students when barriers to participation exist in University courses, programs, or activities.

If you have a documented disability and need to request academic accommodations in your courses, please refer to the SDS website at sds.umbc.edu for registration information and office procedures.

SDS email: disAbility@umbc.edu

SDS phone: 410-455-2459

If you will be using SDS approved accommodations in this class, please contact the instructor to discuss implementation of the accommodations. During remote instruction requirements due to COVID, communication and flexibility will be essential for success.

- **Sexual Assault, Sexual Harassment, and Gender Based Violence and Discrimination**

UMBC Policy in addition to federal and state law (to include Title IX) prohibits discrimination and harassment on the basis of sex, sexual orientation, and gender identity in University programs and activities. Any student who is impacted by sexual harassment, sexual assault, domestic violence, dating violence, stalking, sexual exploitation, gender discrimination, pregnancy discrimination, gender-based harassment, or related retaliation should contact the University's Title IX Coordinator to make a report and/or access support and resources. The Title IX Coordinator can be reached at titleixcoordinator@umbc.edu or 410-455-1717.

You can access support and resources even if you do not want to take any further action. You will not be forced to file a formal complaint or police report. Please be aware that the University may take action on its own if essential to protect the safety of the community.

If you are interested in making a report, please use the Online Reporting/Referral Form. Please note that, if you report anonymously, the University's ability to respond will be limited.

Notice that Faculty and Teaching Assistants are Responsible Employees with Mandatory Reporting Obligations

All faculty members and teaching assistants are considered Responsible Employees, per UMBC's Policy on Sexual Misconduct, Sexual Harassment, and Gender Discrimination. Faculty and teaching assistants therefore required to report all known information regarding alleged conduct that may be a violation of the Policy to the Title IX Coordinator, even if a student discloses an experience that occurred before attending UMBC and/or an incident that only involves people not affiliated with UMBC. Reports are required regardless of the amount of detail provided and even in instances where support has already been offered or received.

While faculty members want to encourage you to share information related to your life experiences through discussion and written work, students should understand that faculty are required to report past and present sexual harassment, sexual assault, domestic and dating violence, stalking, and gender discrimination that is shared with them to the Title IX Coordinator so that the University can inform students of their rights, resources, and support. While you are encouraged to do so, you are not obligated to respond to outreach conducted as a result of a report to the Title IX Coordinator.

If you need to speak with someone in confidence, who does not have an obligation to report to the Title IX Coordinator, UMBC has a number of Confidential Resources available to support you:

Retriever Integrated Health (Main Campus): 410-455-2472; Monday – Friday 8:30 a.m. – 5 p.m.; For After-Hours Support, Call 988.

Center for Counseling and Well-Being (Shady Grove Campus): 301-738-6273; Monday-Thursday 10:00a.m. – 7:00 p.m. and Friday 10:00 a.m. – 2:00 p.m. (virtual) Online Appointment Request Form.

Pastoral Counseling via The Gathering Space for Spiritual Well-Being: 410-455-6795;

i3b@umbc.edu; Monday – Friday 8:00 a.m. – 10:00 p.m.

Other Resources

Women's Center (open to students of all genders): 410-455-2714;

womenscenter@umbc.edu;

Monday – Thursday 9:30 a.m. – 5:00 p.m. and Friday 10:00 a.m. – 4 p.m.

Shady Grove Student Resources, Maryland Resources, National Resources.

Child Abuse and Neglect

Please note that Maryland law and UMBC policy require that faculty report all disclosures or suspicions of child abuse or neglect to the Department of Social Services and/or the police even if the person who experienced the abuse or neglect is now over 18.

- **Pregnant and Parenting Students**

UMBC's Policy on Sexual Misconduct, Sexual Harassment and Gender Discrimination expressly prohibits all forms of discrimination and harassment on the basis of sex, including pregnancy. Resources for pregnant, parenting and breastfeeding students are available through the University's Office of Equity and Civil Rights. Pregnant and parenting students are encouraged to contact the Title IX Coordinator to discuss plans and ensure ongoing access to their academic program with respect to a leave of absence – returning following leave, or any other accommodation that may be needed related to pregnancy, childbirth, adoption, breastfeeding, and/or the early months of parenting.

In addition, students who are pregnant and have an impairment related to their pregnancy that qualifies as disability under the ADA may be entitled to accommodations through the Office of Student Disability Services.

- **Religious Observances & Accommodations**

UMBC Policy provides that students should not be penalized because of observances of their religious beliefs, and that students shall be given an opportunity, whenever feasible, to make up within a reasonable time any academic assignment that is missed due to individual participation in religious observances. It is the responsibility of the student to inform the instructor of any intended absences or requested modifications for religious observances in advance, and as early as possible. For questions or guidance regarding religious observances and accommodations, please contact the Office of Equity and Civil Rights at ecr@umbc.edu.

- **Hate, Bias, Discrimination and Harassment**

UMBC values safety, cultural and ethnic diversity, social responsibility, lifelong learning, equity, and civic engagement.

Consistent with these principles, UMBC Policy prohibits discrimination and harassment in its educational programs and activities or with respect to employment terms and conditions based on race, creed, color, religion, sex, gender, pregnancy, ancestry, age, gender identity or expression, national origin, veterans status, marital status, sexual orientation, physical or mental disability, or genetic information.

Students (and faculty and staff) who experience discrimination, harassment, hate, or bias based upon a protected status or who have such matters reported to them should use the online reporting/referral form to report discrimination, hate, or bias incidents. You may report incidents that happen to you anonymously. Please note that, if you report anonymously, the University's ability to respond may be limited.