

Mobile Embedded Systems and On-device AI

1. INTRODUCTION:

This course introduces computing principles in mobile embedded systems and artificial intelligence technologies on mobile devices. This course focuses on emerging computing paradigms in the areas of context-aware pervasive systems, spatiotemporal access control with distributed software agents, mobile sensing, and trust and privacy in mobile environments. The course also introduces techniques for implementing artificial intelligence (AI) and developing deep learning models on resource-constrained mobile devices. The students will be proficient with fundamental computing methods by studying the programming aspects in sensors and mobile devices. They will learn how to program with sensor nodes, Raspberry Pi, RFID or smartphones and practice sensing data processing on mobile devices. Furthermore, students will develop skills in creating efficient machine learning models suitable for mobile platforms. They'll master the art of constructing deep learning models using Python with PyTorch library and will discover advanced model compression techniques to optimize model performance on mobile devices. The course also introduces adversarial machine learning, where subtle perturbations to input data can deceive machine learning models. The course is cross listed for senior undergraduates and graduate students.

3. COURSE LEARNING OBJECTIVES:

1. Students will learn the knowledge of computing principles of embedded systems supporting mobile technologies.
2. Students will understand the methodology of distributed sensing agents and access control systems.
3. Students will learn mobile sensing pipelines and its data collection and data analysis methodology.
4. Students will learn the energy consumption requirements in mobile embedded systems.
5. Students will learn the programming aspects in sensors via smartphones, RFID tags, and Raspberry Pi.
6. Students will learn the fundamental knowledge of developing machine learning models.
7. Students will learn advanced model compression to optimize model performance on mobile devices.
8. The students also learn adversarial machine learning, where subtle perturbations to input data can deceive machine learning mode

Classroom Location: Core 538
 Instructor: Dr. Yingying (Jennifer) Chen
 Contact Info: yingche@scarletmail.rutgers.edu, Core 506
 Prerequisite(s): some knowledge of C ++ or Java
 Corequisite(s): None

Pre-requisite Courses: None

COURSE MATERIALS

Textbook & Materials

- Lecture notes and handouts will be posted in Canvas.
- No official Textbook is required.
- Sensor equipment will be distributed in the class (e.g., smartphones and sensor nodes)

Topics Covered week by week:

	Date	Lecture	Topics
Week 1	9/11	Lecture 1: Course Organization and Introduction to Internet	Introduction to course goals, requirements, and grading policy;
Week 2	9/18	Lecture 2: Wireless Networks	Overview of Internet and unique characteristics of wireless networks
Week 3	9/25	Lecture 3: Inertial Sensors; Mobile Embedded Sensing	Mobile sensing basics: inertial sensors, anatomy of mobile sensing applications, ground truth, and evaluation criteria.
Week 4	10/2	Quiz 1	
Week 5	10/9	Lecture 4: Mobile Signal Processing	Understanding the basics of time and frequency domain representations of signal; understanding different phases of sensor data analysis cycle
Week 6	10/16	Lecture 5: Machine Learning Basics	Evolution in machine learning; overview of machine learning applications, formulation, and techniques
Week 7	10/23	Quiz 2	
Week 8	10/30	Lecture 6: Energy Constraints in Embedded Systems Midterm Paper Submission	Energy consumption in mobile systems
Week 9	11/6	Lecture 7: Model Compression for Mobile Devices, Error Detection and Correction	Realization of machine learning on mobile devices; error detection and correction basics
Week 10	11/13	Lecture 8: Medium Access Control in Internet	Distributed medium access control methods

Week 11	11/20	Lecture 9: Secret Key Generation, Authentication, & Digital Signatures	Secret key generation, authentication, digital signatures, firewalls
Week 12	11/27	Quiz 3; Lecture 9: Internet Security Threats & Secure Email;	Message digest, secure e-mail, and Internet security threats
Week 13	12/4	Lecture 11: Adversarial Machine Learning	Adversarial attacks and backdoor attacks
Week 14	12/11 (Last class)	Lecture 12: Switching and Spanning Tree in Internet	Tree algorithms in Internet
Final	12/18		

Assessment:

Attendance	(12%)
In-class questions and answers	(12%)
Individual Presentation	(15%)
Quizzes (3)	(30%)
Midterm	(16%)
Final Project & Team Presentation	(15%)

Information on all of the following resources, and many more, can be found at <https://success.rutgers.edu/>

Academic Integrity

115 College Avenue, New Brunswick | (848) 932-9414 | academicintegrity.rutgers.edu

Academic integrity is essential to the success of the University's educational and research missions, and violations of academic integrity constitute serious offenses against the entire academic community. Every member of the University community bears a responsibility for ensuring that the highest standards of academic integrity are upheld.

The university asks that faculty include the following statement for students to sign on all exams and major assignments:

On my honor, I have neither received nor given any unauthorized assistance on this examination (assignment, paper, quiz, etc.).

Websites are available with resources for faculty and students on maintaining academic integrity. The websites provide advice on how to avoid cheating and foster a culture of accountability as well as information on the University Academic Integrity Policy and Procedures.

- Resources for Faculty: nbprovost.rutgers.edu/academic-integrity
- Resources for Students: nbprovost.rutgers.edu/academic-integrity-students

Absences Verification and Student Support

Dean of Students Office | 88 College Ave | studentsupport.rutgers.edu

All students, including student athletes, are responsible for the timely notification of their instructors regarding any expected absences. They are also responsible for making up the missed work and/or exams according to an appropriate schedule agreed upon with their instructors. If students know in advance of an absence, then they must submit the Self-Reporting Absence Application (sims.rutgers.edu/ssra).

Faculty should not ask students for verification of extended absence due to illness (including COVID-19), personal or family emergency, conference, corporate or graduate school interview, etc. Students should be directed to the [Dean of Students Office](#). The Dean of Students will request documentation from the students to verify their absence and will then email the students' professors.

The Dean of Students does not have a way to verify short-term absences and only provides notes when students have prolonged absences. Usually, FERPA and HIPPA limit the information the Dean of Students will provide regarding the reason for the absence, but if the student has a Dean of Students note, that means that there is a serious and compelling, verified reason for the absence.

Please note that the Dean of Students Office does NOT provide verification for students' personal obligations such as weddings, birthday celebrations, or other planned personal or family commitments. In such cases, students would need to present and explain the situation to the instructor, and the final decision for any accommodation is up to the instructor. Please visit soe.rutgers.edu/absence-exams for more information on handling absence or exam conflicts.

A global pandemic results in illness – both among our students and among their family members. Under these circumstances, professors may choose to offer flexibility in excused absences and attendance policies, and to allow make-up work.

Course or Semester Withdrawal

Online or Visit Engineering B100 | soe.rutgers.edu/academic-advising-and-policies/registration-and-scheduling

- 9/14/23: Last day to drop classes without a "W", and last day to add a class.
- 10/30/23: Last day to drop classes via WebReg.
- 11/13/23: Extension last day to drop an SoE class (14:###:###). Must email or meet with an academic advisor or dean.
- December 13, 2023: Last Day of Classes
- December 15, 2023: Last day to withdraw from school (all classes with "W" grades, no refund, must submit a semester withdrawal form)

University Policy on Exam Scheduling and Conflicts

Office of Registrar and Scheduling

scheduling.rutgers.edu/scheduling/exam-scheduling/final-exam-policies

scheduling.rutgers.edu/scheduling/exam-scheduling/final-exam-schedule

Tutoring, Academic Coaching, Learning Support

Rutgers Learning Centers | (848) 445-0986 | rlc.rutgers.edu/ & success.rutgers.edu

Academic coaching is a comprehensive service for students who want to improve their academic and self-management skills, such as time management, organization, and study skills. The Rutgers Learning Centers offer this support, along with tutoring and study groups to help students achieve their academic goals along with self-advocacy and independent, life-long learning. They also have information on how to be a successful learner in an online environment.

Student Wellness

Counseling, ADAP & Psychiatric Services (CAPS)

17 Senior Street, New Brunswick | (848) 932-7884

health.rutgers.edu/medical-counseling-services/counseling/

CAPS is a university mental health support service that includes counseling, alcohol and other drug assistance, and psychiatric services staffed by a team of professionals within Rutgers Health Services to support students' efforts to succeed at Rutgers University. CAPS offers a variety of services that include individual therapy, group therapy and workshops, crisis intervention, referral to specialists in the community and consultation and collaboration with campus partners. They continue to be available online.

Violence Prevention & Victim Assistance (VPVA)

3 Bartlett Street, New Brunswick | (848) 932-1181 | vpva.rutgers.edu/

The Office for Violence Prevention and Victim Assistance provides confidential crisis intervention, counseling and advocacy for victims of sexual and relationship violence and stalking to students, staff and faculty. To speak with someone immediately, call 848-932-1181.

Office of Disability Services

Lucy Stone Hall, Suite A145, Livingston Campus | (848) 445-6800 | ods.rutgers.edu

Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the Office of Disability Services, participate in an intake interview, and provide documentation. If the documentation supports a student's request for reasonable accommodations, the Office of Disability Services will provide you with a Letter of Accommodations. Students then share this letter with their instructors and discuss the accommodations with them as early in the courses as possible.

Advising

SoE Office of Academic Services

Engineering B100, Busch Campus | (848) 445-2212 | soe.rutgers.edu/oas/advising

Undergraduate advisors and deans at the School of Engineering are available to assist students with inquiries related to course planning, academic policies, professional development, scholastic standing, degree progress, withdrawal options, and more.

Advising will be offered in person and online. Students can visit soe.rutgers.edu/oas/advising for appointments or drop-in meetings with an advisor. Drop-in advising will only be online.