SYSEN 5410: Cyber-Physical Systems

Course Info:
Course Title: Cyber-Physical Systems
Author: Jonathan Jaramillo
Revision Data: 1/15/25
Credit Hours: 4

Course Overview: Cyber-Physical Systems (CPS) is a comprehensive course designed for students interested in the integration of computational and physical systems. It covers core concepts such as sensors, actuators, communication protocols (e.g., I2C, SPI, Wi-Fi, Bluetooth), signal processing, computer vision, and control algorithms essential for modern systems like autonomous vehicles, smart grids, and robotics. Through hands-on labs, students will gain practical experience in programming microcontrollers (Raspberry Pi Pico W), system integration, and problem-solving by implementing an autonomous robotic platform (Sparkfun XRP). The course emphasizes design trade-offs, systems architecture, and adaptability to new technologies, preparing students for careers in industries where CPS is increasingly critical. Whether you're a systems engineer, or someone passionate about integrating emergent technologies to solve real-world problems, this course equips you with the tools to tackle complex, interdisciplinary challenges in CPS.

When Offered: Spring, on-campus

Prerequisites/Corequisites: must have familiarity with C++ and Python.

Learning Outcomes:
- Demonstrate proficiency and familiarity with a broad range of technologies used in cyber-physical systems.
- Be able to analyze complex cyber-physical systems and design subsystems, interfaces, and broader system architecture.
- Analyze design trade-offs within a cyber-physical system to optimize system performance and meet end user requirements.

Textbooks and/or Required Materials: The course will use a robotic lab kit for weekly labs. The lab kit consists of an XRP robot, proximity sensor, Raspberry Pi Zero 2 w, and camera. The total cost of the kit is $120, and students are allowed to keep the finished robot at the end of the course.

Class Schedule:
Lectures: Mon/Wed 8:40-9:55 in Hollister 206
Recitation: Friday 9:05-9:55 in Snee 2152
Office Hours: TBD

Assignments, Attendance, Exams, and Projects:
Weekly Labs: Each week students will be assigned a take-home lab and report due by the following week. These labs will be incremental, building towards a completed cyber-physical system by the end of the semester. This year's lab project will be an autonomous robot capable of conducting high level computer vision tasks such as object detection, tracking, and navigation.
Attendance: students are expected to attend all lectures and recitations. Additional in-person, pass/fail pop quizzes may be assigned once per weekly randomly to enforce attendance policy.
Case Studies: There will be 3-4 case studies assigned as group projects throughout the semester.
Exams: There will be ***no prelims or finals*** for this course. In its place, there will be a final lab assignment which will be open-ended and culminate everything learned throughout the course.

Course Grading Scheme: Labs - 60%, Case studies - 30%, Participation - 10%

Topics Covered

- Cyber-physical system architectures and frameworks
- Computational systems and computer architectures
- Embedded systems and cloud computing platforms
- Computer programming languages and paradigms
- Wired and wireless communication protocols
- Sensors and sensor networks
- Actuators
- Signal processing and computer vision

Academic Integrity, AI, and Grading:
Students are expected to abide by the Cornell University Code of Academic Integrity with work submitted for credit representing the student's own work. Students are permitted to use generative AI tools such as ChatGPT and github copilot to assist with computer programming tasks and writing. However, students are responsible for the quality of their work. Points may be deducted for large amounts of low-quality or relevant AI generated material in reports.