Connected and Autonomous Vehicles: Challenges and Design
Winter 2024

The development of ADAS (advanced driver-assistant systems) and autonomous driving functions, as well as various short- and long-range connectivity technologies, has propelled the rapid advancement of modern vehicles. However, it has also presented significant challenges to vehicle design, particularly in addressing high-volume and dynamic sensing inputs, enabling complex computation and communication architectures, and ensuring system safety, security, performance, reliability, and extensibility. Moreover, this trend not only affects the design of individual vehicles but also the operation of entire vehicular transportation system, in connected vehicle applications such as intelligent traffic signals, collaborative adaptive cruise control (CACC), and vehicle platooning.

This course will introduce the major trends and challenges in the design of connected and autonomous vehicles, present promising solutions, and discuss future directions. The course will cover both core technical subjects and various case studies.

Course Instructor:

Prof. Qi Zhu, Tech L454, qzhu@northwestern.edu.

Schedule:

Week 1: Introduction – overview of CAVs, major trends and challenges in autonomous vehicles and vehicular networks.

Week 2&3: Sensing and Perception – sensors, overview of sensing and perception algorithms (data representation, segmentation, object detection, localization).

Week 3&4: Planning and Control – route planning, behavior planning, trajectory and motion planning, low-level feedback control.

Week 5&6: Software and Hardware – overview of automotive software, RTOS, scheduling, in-vehicle communication protocols (CAN, FlexRay, TSN).

Week 7&8: Synthesis – overview of automotive software synthesis and optimization, AUTOSAR, in-vehicle security, fault tolerance, extensibility.

Week 9&10: Connected Vehicles – overview of connected vehicle applications, overview of vehicular network protocols (DSRC, C-V2X), security and timing in connected vehicles, examples in autonomous intersections, CACC, lane merging.

Course Project:

For course project, students will select from a list of topics on connected and autonomous vehicles (or propose their own), conduct literature survey, propose solutions, and carry out preliminary analysis. Students are encouraged to team up. Each team should submit a report in ACM/IEEE double-column format (no less than 6 pages for two-person team, excluding references).

Grading:

Homework 40%, course project 60%.

Class Recording:

This class or portions of this class will be recorded by the instructor for educational purposes. Your instructor will communicate how members of the class can access the recordings. Portions of the course that contain images, questions, or commentary/discussion by students will be edited out of any recordings that are saved beyond the current term.