CS 695: Connected and Automated Vehicles

Course Description:

This course addresses the research and engineering challenges encountered in designing, implementing, and deploying connected automated vehicles. They include sensing, recognition, planning, control and communication aspects for vehicles and roadside infrastructure. The connected automated vehicles are expected to improve the safety and comfort of all traffic participants including the vehicle occupants, bicyclists and pedestrians while minimizing the environmental impact of traffic. In addition, providing the right of way for emergency vehicles and traffic arrangements around special events and parking in congested cities need to be addressed in a comprehensive framework for connected automated vehicles.

Course Teaching:

The course will be taught by Dr. Zoran Duric and occasionally by guest lecturers. A significant part of the course will include experimenting in the lab and the field. The lab is equipped with driving simulators, traffic signaling equipment and multiple sensors including video and thermal cameras, radars, lidars and high-precision GPS. The available equipment includes three cars that can be mounted with sensor packages.

Class Meetings:
Synchronous at the Arlington campus at 1:30-4:15pm on Fridays. Smaller groups of students will meet at the Arlington CCI/Cymanii laboratory at Vernon Smith Hall.

Grading:
The grade will be based on 3-4 small individual projects and one large semester long group project. The large project will be weighted 60% and the smaller projects will count for the remaining 40% of the course grade. For the larger project, the groups will spend 5 weeks reading publications related to the topic of the group's choosing and present a project proposal in the fifth week. After evaluation, the groups will be given suggestions for improvements and assigned a mentor, who will have bi-weekly meetings with the group.

Prerequisites:

All students are expected to have reasonable coding capability (Python or Matlab) and be able to model, implement and test the models using a simulation environment specified for the different assignments. The students are expected to know the experimental procedure, validation, data gathering and making validating hypotheses using statistical data analysis or a similarly accepted method in engineering or science.

Approximate Syllabus: The course will cover the following topics in the listed nominal order (that may change based on class progress).

1. **Introduction:** A broad overview of all traffic-related problems. Levels of automation. the role of various parts including infrastructure, network, and traffic participants. Smart vehicles, infrastructure, connectivity. Maps and planning. Low-level planning and driving, parking. Security, privacy, and comfort levels. Human driving vs. fully automated vs. mixed traffic on roads.
2. **Sensing and smart vehicles:** Driving, roads and pedestrians, highways vs. secondary roads. Connectivity and interaction with networks. Knowledge extraction from multiple sensors.
3. **Basic vehicular dynamics and road geometry**: Equations of motion, vehicular stability, slip and slide, and different levels of controls.
4. **Planning and Route computation:** 3-level route planning algorithms.
5. **Control Systems for Autonomous Driving:** Model Predictive Control and IDP Controllers for autonomous driving system, their safety.
6. **Communication:** Basic Safety Messages (BSM), DSRC and 5G CV2X, Road-side units and traffic signaling. CanBus and vehicular Ethernet.
7. **Safety Evaluations:** NHSTA recommendations and emerging SAE standards.
8. **Special Topics:** Electric vehicles, hybrid electric vehicles and emerging electric vehicles charging system models and protocols.