# CS/ISA 695: Research Issues in Connected and Automated Vehicles

**Course Description:**

This research oriented course addresses the research and engineering challenges faced in designing and implementing connected automated vehicles. These involve multiple aspects of sensing, recognition, control and communication aspects for vehicles and road-side infrastructure. Two important aspects of automated and connected vehicles are the need to minimize traffic delays and congestion while being cognizant and accommodating the needs of pedestrians, bicyclist and other entities that need to share the roads and roadside spaces. In addition, special needs such as providing the right of way for emergency vehicles and traffic arrangements around special events and parking in congested cities are issues that needs to be addressed in a comprehensive framework for connected automated vehicles. The class will discuss current topics related to communication standards such as 5G/DSRC, basic Safety Message Systems etc., and how they would work with existing traffic signals and vehicular control. Rudimentary aspects of vehicular dynamics and communications inside vehicles using the CAN protocols and vehicular ethernet will also be discussed. The safety and cyber security aspects of the components will receive attention in all the discussed topics. The class will be taught online using blackboard in a synchronous mode.

**Course Administration:**

There will be 2 to 4 smaller projects (extended homework like) and a semester long project will be considered for grade assignment. The smaller projects will be individual, but the larger project will be done in smaller groups of students.

**Class Meetings:**

Synchronous on Blackboard
Time: 4.30-7.10pm

**Grading:**

The large project will be weighted 60% and the smaller projects will count for the other 40% of the course grade. For the larger project, the group will spend 5 weeks reading publications related to 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 a reasonable coding capabilities and be able 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, date gathering and making validating hypothesis using statistical data analysis or a similarly accepted method in engineering or science.

**Approximate Syllabus:** The course will attempt to 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 part including infrastructure, network, traffic participants. Smart vehicles, infrastructure, connectivity. Maps and planning. Low level planning and driving. Parking etc. Security, privacy and comfort levels. Human drive vs. fully automated vs. mixed traffic on roads. **[Small Project 1 given out: Urban Traffic Simulation using SUMO]**
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. **[Small Project 2 Given out: Sensor Fusion]**
4. **Planning and Route computation:** 3-leve 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.
7. **Cyber Security and Security Credential Management Systems:** Enforcing privacy and unlikability, accountability and misbehavior detection. **[Small Project 3 Given out: Model Predictive Control using MathLab]**
8. **Communications inside an automobile:** CanBus and vehicular Ethernet
9. **Safety Evaluations:** NHSTA recommendations and emerging SAE standards
10. **Special Topics:** Electric vehicles, hybrid electric vehicles and emerging electric vehicle charging system models and protocols.