Connected Autonomous Electric Vehicles
Spring 2023
ME379M (19170) / ME397 (193750
ECE 394J (17790) / ECE 379K (17580)
CS 378 (52433)
Walker Department of Mechanical Engineering
Department of Electrical and Computer Engineering
Department of Computer Science
University of Texas at Austin

Instructors
Prof. Joydeep Biswas, Email: joydeepb@cs.utexas.edu
Prof. Junmin Wang, Email: jwang@austin.utexas.edu.
Prof. Alex Huang, Email: aqhuang@utexas.edu
Lectures: 1:00pm – 2:00pm, Mondays, Wednesdays, and Fridays; ECJ 1.204
Office Hours: See the course schedule table.

Teaching Assistants
TA contacts: see schedule table
TA office hours: see schedule table

Prerequisite
Undergraduate students and graduate students should have rudimentary understanding on dynamic systems and controls.

Objectives and Scope
This course aims to provide undergraduate and graduate students with multidisciplinary knowledge on the principles, analyses, system designs and integration of autonomy / automation, connectivity, and electrification technologies for ground vehicles. A project will be conducted throughout the course.

Course Structure and Topics
The course has three main phases taught by three instructors from Computer Science, Mechanical Engineering, and Electrical and Computer Engineering Departments, respectively.

Phase I: Vehicle Perception and Autonomy introduces key functions and methods in vehicle perception and planning.

Phase II: Vehicle Automation and Connectivity introduces physics-based vehicle dynamic modeling and motion control methods with automation and connectivity functions.

Phase III: Electric Vehicle Powertrain introduces the main propulsion components of battery powered electric vehicles.

Tentative Course Schedule

<table>
<tr><th colspan="2">Phase I: Vehicle Perception and Autonomy</th></tr>
<tr><td colspan="2">Instructor: Prof. Joydeep Biswas; Email: joydeepb@cs.utexas.edu
Office hour: 9:00am – 10am on Mondays, GDC 3.512</td></tr>
<tr><td colspan="2">TA: Rahul Menon; Email: rmeno12@utexas.edu
Office hour: 5:00pm – 6:00pm on Wednesdays, GDC 1N Basement Computer Lab</td></tr>
<tr><td colspan="2">Duration: Jan. 9 – Feb. 10 (Jan. 16 Martin Luther King, Jr. Day)</td></tr>
<tr><th>Week</th><th>Topic</th></tr>
<tr><td>1</td><td>Kinematics of Ackermann steering, 1-D time-optimal control</td></tr>
<tr><td>2</td><td>Latency compensation, Longitudinal control (AEB)</td></tr>
<tr><td>3</td><td>LIDAR Sensing, obstacle detection, Lateral control (AEB)</td></tr>
<tr><td>4</td><td>Obstacle avoidance, local planning</td></tr>
<tr><td>5</td><td>Closing the loop: Real-time dynamic obstacle avoidance</td></tr>
<tr><th colspan="2">Phase II: Vehicle Automation and Connectivity</th></tr>
<tr><td colspan="2">Instructor: Prof. Junmin Wang; Email: jwang@austin.utexas.edu.
Office hour: 1:00pm – 2:00pm on Tuesdays, ETC 4.152C, or by email appointments</td></tr>
<tr><td colspan="2">TA: Xingyu Zhou; Email: xingyu.zhou@austin.utexas.edu
Office hour: 5:00pm – 6:00pm on Tuesdays via Zoom through Canvas</td></tr>
<tr><td colspan="2">Duration: Feb. 13 – March 24; (spring break: March 13 - 18)</td></tr>
<tr><th>Week</th><th>Topic</th></tr>
<tr><td>6</td><td>CAEV overview and ground vehicle modeling and efficiency characterization</td></tr>
<tr><td>7</td><td>Vehicle dynamics and motion control: sensors, actuators, and systems</td></tr>
<tr><td>8</td><td>Vehicle path-following and trajectory-tracking control</td></tr>
<tr><td>9</td><td>Human driver modeling and human-centric vehicle automation</td></tr>
<tr><td>10</td><td>Connected, electric, and automated vehicles: applications and potentials</td></tr>
<tr><th colspan="2">Phase III: Electric Vehicle Propulsion</th></tr>
<tr><td colspan="2">Instructor: Prof. Alex Huang; Email: aqhuang@utexas.edu
Office hour: 3:00pm – 4pm on Mondays, EER 7.878, or by email appointments</td></tr>
<tr><td colspan="2">TA: Patrick Han, patrickhan@utexas.edu
Office hour: 4-5pm, Mondays, location TBD. Please check Canvas for update</td></tr>
<tr><td colspan="2">Duration: March 27 - April 24</td></tr>
<tr><th>Week</th><th>Topic</th></tr>
<tr><td>11</td><td>EV Powertrain Overview, EV Powertrain Market Trends
Control Architecture / Vehicle Communication Networks / Supervisory Controller Functions</td></tr>
<tr><td>12</td><td>Motor Drives Intro, PMSM Modelling, PMSM Control</td></tr>
<tr><td>13</td><td>Traction Inverters</td></tr>
<tr><td>14</td><td>Traction Battery Intro + Battery Modelling, Battery Modelling, BMS Functions</td></tr>
<tr><td>15</td><td>Onboard Chargers, DC Fast Chargers</td></tr>
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Textbook and References
No textbook required. Lecture notes, references, and reading materials will be provided.

Course Project
In this course, students will implement the building blocks of a modem Connected Autonomous Electric Vehicle (CA-EV), in three milestones:
Milestone 1 will operate at a high-level sensing and control abstraction, and will implement autonomous obstacle avoidance in a real-time simulated environment.
Milestone 2 will cover details on the dynamics of a vehicle, and how to implement robust controllers. Students will implement simulated dynamics controllers in Matlab/Simulink simulations for this milestone.
Milestone 3 will cover details on motor control and power management for an EV, and how to convert dynamics commands to actuation with at the motor control level. Students will implement power controllers in Matlab for this milestone.

Project Teaming and Reporting
- Project teaming by end of the first week.
- All three project milestones will be implemented in project groups of up to four students per group.
- Each project group must have students from *at least two departments*, but are strongly encouraged to have representation from all three departments (CS, ECE, ME).
- All project milestones will consist of intermediate checkpoints. Each of the checkpoints and milestones will require a progress report.

Grading Policy
Please bring any questions or concerns about grading to the respective instructor as soon as possible after the item in question has been graded. Letter grades will be assigned based on the weighted total score. Each milestone will be worth 33.33% of the total score, of which 5% is allocated for individual contribution assessment.

Course Website
Course materials including syllabus, lecture notes, announcements, homework assignments and solutions will be posted on Canvas: https://utexas.instructure.com/courses/1354261 .

Sharing of Course Materials is Prohibited
No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

Class Recordings
Class recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings.

Miscellaneous Items
- The deadline for dropping a course without possible penalty can be found in the current semester UT calendar online at: https://registrar.utexas.edu/
- Allegations of Scholastic Dishonesty will be dealt with according to the procedures outlines in Appendix C, Chapter 11 of the General Information Bulletin:

- https://registrar.utexas.edu/catalogs
- Student misconduct and academic integrity issues will be reported to Office of the Dean of Students http://deanofstudents.utexas.edu/conduct/reportanincident.php
- Students with disabilities may request appropriate academic accommodations from the Division of Diversity and Community Engagement (DDCE), Services for Students with Disabilities (SSD) at http://ddce.utexas.edu/disability.
- All the submissions must by your own work. Any evidence of plagiarism or other forms of scholastic dishonesty will be grounds for a failing grade of the course.