COURSE SYLLABUS

AuE 8200: Machine Perception and Intelligence

Spring 2022 Credit: 3 Department of Automotive Engineering

SCHEDULE AND LOCATION:

Tues. and Thur.: 10:45 - 12:00 PM Classroom 404 Greenville, CU-ICAR
Teaching mode: **In-person**. Zoom for medical/COVID absence attending class online:
https://clemson.zoom.us/j/94372449687?pwd=a2hRMnI2SkREV0xhTi9GRDhOU2psdz09

INSTRUCTOR

Bing Li, Ph.D., Assistant Professor CGEC 340 bli4@clemson.edu
Office hours (above Zoom): Thur. 12 - 1:30 pm, or by appointment for other time/in-person

TA(s):

Zack Yang, CGEC 3rd floor, Cubicle #77 zongmiy@clemson.edu
Office hours (above Zoom): Mon. 1:30 - 3:30 pm, or by appointment for other time/in-person
Ziyue Feng, CGEC 3rd floor, Cubicle # 60 zfeng@clemson.edu
Office hours (above Zoom): Wed. 9:30 - 11:30 am, or by appointment for other time/in-person

WEBSITE:

http://www.clemson.edu/canvas (Slides and class recordings will be uploaded in Files)
All homework assignments, slides, materials and submissions use Canvas only.
The instructor and the TA are not responsible for checking email submissions.

COURSE DESCRIPTION

With the increasing demand, scale, and data information of autonomous vehicle systems, perception and sensing is the first stage in the computational pipeline for vehicles to continuously 'see' the surrounding environment as well as tracking their movements. Further, frontier machine intelligence algorithms empower vehicles to recognize scenes and scene context (e.g, objects, and hazards) so that vehicles can make safe and effective decisions. Therefore, there are essential needs to incorporate the fundamental knowledge and skillsets of perception and intelligence into curricula for automotive programs.

This course will introduce the fundamental technologies for autonomous vehicle sensors, perception, and machine learning, from electromagnetic spectrum characteristics and signal acquisition, vehicle extrospective sensor data analysis, perspective geometry models, image and point cloud processing, to machine/deep learning approaches. We will also have hands-on programming experience in vehicle perception problems through homework and class projects.

COURSE OBJECTIVES

- For different perceptive sensing modalities in the electromagnetic spectrum, the students will be able to identify their characteristics including pros and cons, and application scenarios;

- Given a perceptive sensing dataset, the students will be able to use related libraries to perform basic and geometric processing for the sensor data;
- Given a perceptive sensing dataset with labeling, the students will be able to use machine learning and deep learning framework and libraries for recognition tasks;

STUDENT OUTCOMES

Upon completing the course, students will be able to:

- Collect and organize appropriate machine perceptual sensor data in autonomous robots and vehicle systems;
- Apply principles of 1D/2D/3D signal/image/point cloud data processing and filter design, and formulate and implement the algorithms;
- Apply machine learning (including deep learning) approaches for perceptual sensor data processing and analysis;
- Evaluate the performance of machine perceptual sensor data processing algorithm results;

PRE-REQUISITES

- University-level math courses such as Linear algebra, Calculus, Trigonometry or Geometry, and basic concepts on Probability or Statistics is preferred.
- Essential programming proficiency (Matlab, Python, C++ or any)

COURSE TOPICS

- Vehicle sensors and signals (2 weeks)
    - Signal, spectrum, and vehicle perception sensors
    - Automotive radar signal processing *[Homework]*
- Vehicle visual perception (6 weeks)
    - Digital image fundamentals (formation, operations, histogramming) *[Homework]*
    - Image formation and processing (filtering, convolution, correlation)
    - Fourier transform and frequency domain processing
    - Image morphological operations and segmentation
    - Feature extraction and representation *[Homework]*
    - 3D perspective projection and camera model review
    - Visual motion and optical flow
    - Tracking and Kalman filtering
    - Geometry and point cloud processing *[Homework]*
- Vehicle simultaneous localization and mapping (SLAM) (3 weeks)
    - Inertial measurement unit (IMU) state estimation
    - Visual odometry and visual SLAM
    - LiDAR odometry and LiDAR SLAM
    - Multi-sensor (Visual/LiDAR/IMU) fusion SALM
- Machine learning for vehicle perception (4 weeks)
    - Machine learning fundamentals

- Supervised, unsupervised, semi-supervised learning
- Deep learning for autonomous driving
  - Deep learning fundamentals
  - Deep learning for Radar detection
  - Deep learning for Camera detection
  - Deep learning for LiDAR detection *[Homework]*
  - The synthetic dataset for vehicle perception
  - Deep learning for driver behavior analysis
- (Deep) reinforcement learning (RL) for end-to-end driving
- Course Final Project

COURSE GRADING POLICY

- Homework: 40%
- Projects Implementation/Presentation: 30%
- Projects Report: 30%
- Cumulative percentage scores to letter grades with Graduate School GPA Policy:

>= 92%	(92-88]	(88-84]	(84-80]	(80-77]	(77-74]	(74-68]	(68-60]	< 60%
A	A-	B+	B	B-	C+	C	C-	F
4.00	3.67	3.33	3.00	2.67	2.33	2.00	1.667	0.00

PROJECTS

- Projects are intended to be done in groups up to (<=) 3 students. The students will form the team voluntarily and the instructor will do the necessary adjustments.
- The instructor will list project topic candidates. With a one-page writing proposal, students are open and welcome to propose and discuss with the instructor for self-chosen projects, which shall be closely related to the scope of sensor, perception, and autonomy, or can be using these techniques to solve other domain problems. Self-chosen projects need to be approved by the instructor as class final projects.
- Project moves on with three steps: Review, Proposal and Final. The literature review summary is due 2 days before the Review presentation day. Preliminary results are expected in Proposal presentation. Project, presentation, and the report will be graded based on both individual contribution and team project results. Therefore, the role of each individual should be declared clearly in presentation slides and reports.

ATTENDANCE POLICY

Attendance in all classes is mandatory. The instructor will take attendance occasionally and use it to adjudicate borderline grades. Each absence will get docked by 2 scores on your final grade score (which actually affect a lot!). Students with more than (>=) 5 absences will not receive a passing grade in the class. If you miss a class, it will be your responsibility to make up the content discussed in this class.

LATE POLICY

- This course moves quickly. Homeworks are assigned to help you with class learning. Late assignments and reports are docked by 4 scores for each late submission day with the maximum docking 20 scores. All homework will be submitted electronically and the instructor/TAs are not responsible to check email submissions.
- All homework or exam grading complaints must be resolved within one week after it is turned back from the instructor. It's your responsibility to follow up first with the grading teaching assistant then the instructor within one week.

TEXTBOOK & REFERENCE MATERIALS

- No textbook is required. All concepts will be covered in class lecture, and in the lecture slides. Course notes and some reading materials will be placed on Canvas. However, we also recommend the following materials as good references:
- Digital Image Processing: Rafael Gonzalez, Pearson Press
- Computer Vision: Algorithms and Applications. Richard Szeliski, Springer
- Machine Learning: Tom Mitchell, McGraw-Hill
- Deep Learning: Ian Goodfellow, MIT Press

COLLABORATION POLICY AND HONOR CODE

- Collaboration is encouraged. However, it's important that the work you submit is an expression of your understanding, and not merely what you copied from other sources. Cheating is prohibited and will carry serious consequences. Cheating may be defined as using or attempting to use unauthorized assistance, material, or study aids in academic work or examinations.
- You should not share your own code or copy peers' code. You can seek help and discussion from your peers, but should not copy any code segment from any other peer.
- Engineering Honor Code of College is available: http://www.clemson.edu/cecas/current-students/honor-code.html

ACADEMIC CONTINUITY PLAN

Clemson has developed an academic continuity plan for academic operations. Should University administration officially determine that the physical classroom facility is not available, the class will be conducted in a virtual (online) format. The University issues official disruption notifications through email/ www/ test notification / social media. When notified, use one of the following links to navigate for Clemson Canvas, where you will find important information about how we will conduct class:

- Primary access link: www.clemson.edu/canvas
- Secondary access link, if needed: https://clemson.instructure.com/
- You can also use the Canvas Student App.

Our activities for teaching and learning will occur through our Canvas course. This includes: slides and online teaching and learning. On E-Learning Day, a real-time test of the academic continuity plan will be conducted. Our class will be conducted through E-learning online lecturing, please use the Zoom link at the top of this syllabus document.

DISABILITY ACCESS STATEMENT

- It is university policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities. Students with disabilities requesting accommodations should make an appointment with Accessibility Services (656-6848), to discuss specific needs within the first month of classes. Students should present a Faculty Accommodation Letter from Student Accessibility Services when they meet with instructors. Accommodations are not retroactive and new Faculty Accommodation Letters must be presented each semester.

ACADEMIC INTEGRITY STATEMENT

- You may refer to publicly available sources, such as books, journal and conference publications, and web pages, as research material for your answers. You will not lose points for referring to external sources, However, you must clearly and explicitly cite all outside sources, materials, ideas, and approaches that you made use of. We consider the use of verbatim copy or uncited external sources as plagiarism, and as such it is a violation of the University's policies on academic dishonesty. Instances will be dealt with harshly and typically result in serious consequences.
- As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a “high seminary of learning.” Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form.
- In addition, READ the Graduate School’s Academic Integrity Policy: Definitions of Violations, Enforcement Procedures on Clemson Graduate School Policy and Procedures Manual, starting around page 41 of the document for the current academic year. https://www.clemson.edu/graduate/students/policies-procedures/index.html

CLEMSON UNIVERSITY TITLE IX (SEXUAL HARASSMENT) STATEMENT

- Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran’s status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid.
- This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. The policy is located at http://www.clemson.edu/campus-life/campus-services/access/non-discrimination-policy.html (Links to an external site.). Alesia Smith serves as Clemson’s Title IX Coordinator and may be reached at alesias@clemson.edu or (864) 656-3181