# EE6626: AI-ENABLED AUTONOMOUS DRIVING

**Effective Term**
Semester A 2026/27

## Part I Course Overview

**Course Title**
AI-enabled Autonomous Driving

**Subject Code**
EE - Electrical Engineering

**Course Number**
6626

**Academic Unit**
Electrical Engineering (EE)

**College/School**
College of Engineering (EG)

**Course Duration**
One Semester

**Credit Units**
3

**Level**
P5, P6 - Postgraduate Degree

**Medium of Instruction**
English

**Medium of Assessment**
English

**Precursors**
EE3210 Signals and Systems and
SDSC2001 Python for Data Science or equivalent

**Equivalent Courses**
Nil

**Exclusive Courses**
Nil

## Part II Course Details

**Abstract**
This course introduces the technologies that make autonomous driving possible. Modern self-driving vehicles rely on multi-sensor fusion of cameras, LiDAR, radar, GPS, and IMUs to ensure robust perception and eliminate blind spots. AI and machine learning play a central role across the stack: object detection (e.g., Single-Shot Detector(SSD), YOLO, multi-object tracking (e.g., DeepSORT), semantic segmentation of drivable vs. non-drivable space, trajectory prediction, and behavior

modeling of surrounding vehicles. These algorithms enable the vehicle to anticipate how other road users may respond to its maneuvers and to plan safe navigation strategies. In addition, emerging Large Language Models (LLMs) are being explored to enhance reasoning and explainability, providing natural-language feedback to passengers and interpreting traffic context in unstructured environments.

**Course Intended Learning Outcomes (CILOs)**

| | **CILOs** | **Weighting (if app.)** | **DEC-A1** | **DEC-A2** | **DEC-A3** |
|---|---|---|---|---|---|
| 1 | Explain the role of multi-sensor systems (camera, LiDAR, radar, GPS, IMU) in autonomous vehicles and describe how sensor fusion enhances perception and safety. | | x | x | |
| 2 | Understand and describe AI/ML algorithms including object detection, multi-object tracking, localization and mapping, and trajectory prediction to analyze and interpret driving environments. | | | x | x |
| 3 | Design and implement basic perception and prediction tasks using real or simulated sensor data, and assess system performance in practical driving scenarios. | | | x | x |
| 4 | Discuss and evaluate emerging research such as Large Language Models (LLMs) for reasoning, explainability, and human–machine interaction in autonomous driving. | | x | x | |

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

**Learning and Teaching Activities (LTAs)**

| | **LTAs** | **Brief Description** | **CILO No.** | **Hours/week (if applicable)** |
|---|---|---|---|---|
| 1 | Lecture | Through lectures, students can learn and grasp concepts of modern sensor, signal processing, computer vision, AI, technologies and how they are applied in AVs. | 1, 2, 3, 4 | 3 hrs/wk |
| 2 | Case study | Focus on learning how different algorithms work in the complete stack of AV | 2, 3 | |

| | | | | |
|---|---|---|---|---|
| 3 | Labs/Projects | Give students hands-on experience of how various software tools are used in enablers for AV | 2, 3 | 2 projects/semester |

**Assessment Tasks / Activities (ATs)**

| | ATs | CILO No. | Weighting (%) | Remarks ("-" for nil entry) | Allow Use of GenAI? |
|---|---|---|---|---|---|
| 1 | Assignments# | 1, 2, 3, 4 | 30 | - | Yes |
| 2 | Test | 2, 3 | 20 | - | No |

**Continuous Assessment (%)**

50

**Examination (%)**

50

**Examination Duration (Hours)**

2

**Minimum Continuous Assessment Passing Requirement (%)**

30

**Minimum Examination Passing Requirement (%)**

30

**Additional Information for ATs**

To pass the course, students are required to achieve at least 30% in course work and 30% in the examination. Also, 75% laboratory attendance rate must be obtained.

#may include homework, tutorial exercise, project/mini-project, presentation

**Assessment Rubrics (AR)**

**Assessment Task**

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**Criterion**

Achievements in CILOs

**Excellent**

(A+, A, A-) High

**Good**

(B+, B, B-) Significant

**Fair**

(C+, C, C-) Moderate

**Marginal**

(D) Basic

**Failure**

(F) Not even reaching marginal level

**Assessment Task**
Coursework (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**Criterion**
Achievements in CILOs

**Excellent**
(A+, A, A-) High

**Good**
(B+, B, B-) Significant

**Fair**
(C+, C, C-) Moderate

**Marginal**
(D) Basic

**Failure**
(F) Not even reaching marginal level

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**Assessment Task**
Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

**Criterion**
Achievements in CILOs

**Excellent**
(A+, A, A-) High

**Good**
(B+, B) Medium

**Marginal**
(B-, C+, C) Low

**Failure**
(F) Not even reaching marginal level

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**Assessment Task**
Coursework (for students admitted from Semester A 2022/23 to Summer Term 2024)

**Criterion**
Achievements in CILOs

**Excellent**
(A+, A, A-) High

**Good**
(B+, B) Medium

**Marginal**

(B-, C+, C) Low

**Failure**

(F) Not even reaching marginal level

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**Additional Information for AR**

**Constructive Alignment with Programme Outcomes**

PILO 1. Students will be able to understand and describe the fundamental components of an autonomous vehicle (AV), from sensor operation and fusion to AI/ML perception and decision-making techniques.

PILO 2, 3. Will gain hands-on experience through assignments involving sensor data processing and practical case studies in autonomous driving.

PILO 4. Gain understanding of how the full stack of AV technologies work together including: Full AV pipeline: Sensors → Perception → Localization →Prediction → Integration.

PILO 5. Get a good understanding of how real world autonomous vehicle operates and the rationale behind the tradeoffs of different technologies

# Part III Other Information

**Keyword Syllabus**

**Introduction to Autonomous Driving**

History and levels of vehicle autonomy (SAE autonomous levels 0–5); Key challenges (safety, ethics, regulation); Overview of the AI stack in AVs

**Vehicle Sensors**

Cameras, LiDAR, radar, GPS, IMU; Strengths and weaknesses of each; Examples from real AV platforms

**Sensor Fusion**

Data fusion principles (early vs. late fusion); Kalman filters, deep sensor fusion; Practical example: combining radar + camera for vehicle detection

**Object Detection and Tracking**

Introduction to object detection networks: Single-Shot Detector (SSD); Classical multi-object tracking: Kalman filtering for state estimation and the Hungarian algorithm for data association; Modern multi-object tracking (DeepSORT): detection + appearance features + tracking; Homework 1: run SSD on a traffic video and track selected vehicles across frames.

**Perception: Semantic Segmentation (part 1)**

Identification of drivable vs. non-drivable space in road scenes; Introduction to classical computer vision segmentation (e.g. K-mean clustering) – strength and limitations ; Pixel-wise classification using Fully Convolutional Neural network – the deep learning method approach to semantic segmentation

**Perception: Semantic Segmentation (part 2)**

Mid-term exam on concepts and algorithm, covering topics up to week 6; Lane detection (segmentation-based) and traffic light recognition (classification); Hands-on demo: segment roads and sidewalks from images, comparing classical vs. deep learning results

**Localization & Mapping**

Why GPS alone isn’t enough: accuracy limits, urban canyons, tunnels, multipath; Sensor fusion for localization: how IMU helps smooth GPS; Kalman filtering basics; Visual odometry (VO): using camera features tracked frame-to-frame to estimate relative motion; SLAM (Simultaneous Localization and Mapping): jointly building a map and estimating position from multi-sensor data; HD maps and map matching: high-resolution road/lane maps and how AVs align real-time sensor data with them for precise localization.

**Prediction of Dynamic Agents**

Why is prediction needed? What are classical methods and why are they insufficient? Deep learning approaches for trajectory forecasting; Modeling pedestrian vs. vehicle motion; Uncertainty in prediction: handling multiple possible futures (multi-modal prediction)

### Future Trends in AI for AVs

LLMs for reasoning, explainability, and user interaction; Generative AI for simulation scenario creation; End-to-end learning for perception and planning

### Putting It All Together

Full AV pipeline: Sensors → Perception → Localization →Prediction → Integration; Real-world examples: Waymo, Tesla; Discussion of safety, robustness, and ethics in real deployments.

## Reading List

### Compulsory Readings

| | Title |
|---|---|
| 1 | Autonomous Driving Architectures: Insights of Machine Learning and Deep Learning Algorithms [https://www.sciencedirect.com/science/article/pii/S2666827021000827] |

### Additional Readings

| | Title |
|---|---|
| 1 | "YOLOv1–v8 Papers" — Redmon et al., 2016 → Ultralytics updates |