



Automotive Sensors

Course Introduction

Automotive Intelligence Lab.

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Course Staff

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Course Information

■ Communication

- ▶ Hanyang University LMS (<http://lms.hanyang.ac.kr>)
 - Announcements, lecture notes, assignments, etc.

■ Prerequisites

- ▶ Basic programming skills.
 - Any language (C / C++ / Java / Python / MATLAB) experience is fine.
- ▶ A personal computer that can run MATLAB for projects.

■ Textbook

- ▶ Lecture notes are mainly used for lecture.

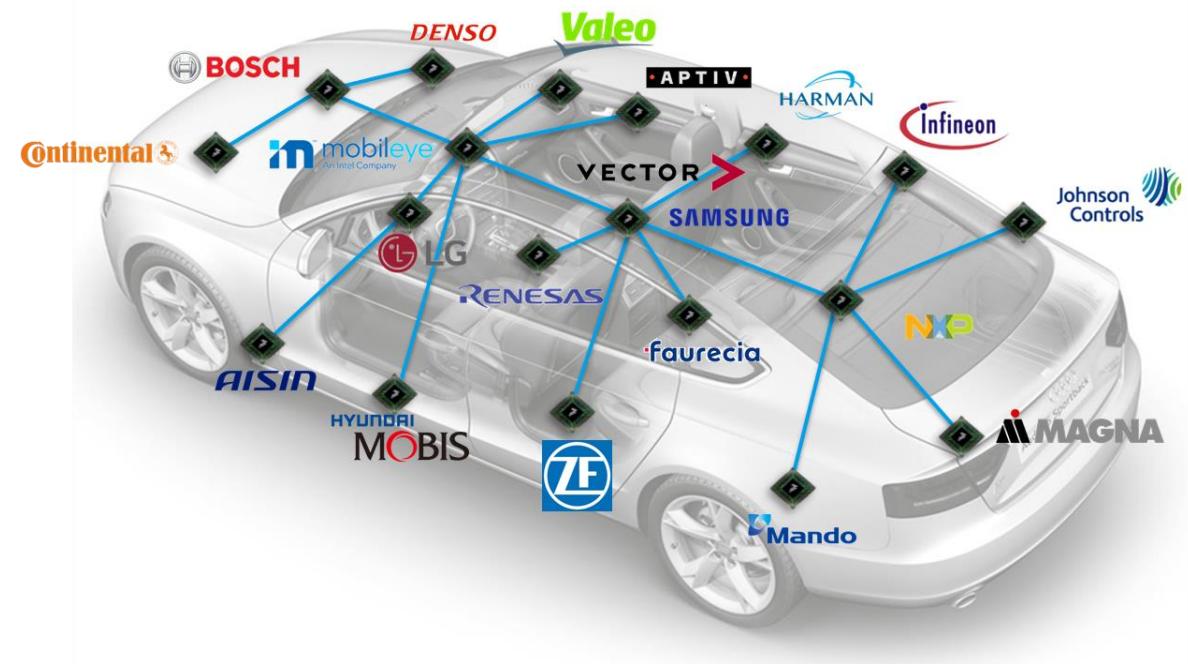
Course background and objectives

Course Objectives

1. Learning the **principles and types of sensors** used in future cars.
2. Learning **sensor interface and data processing technology**.
3. Developing **software capabilities** through sensor data processing practice.

Course Objectives 1

- Learning the **principles** and **types of sensors** used in future cars.
- Learning sensor interface and data processing technology.
- Developing software capabilities through sensor data processing practice.



Automobile in the 1st and 2nd Industrial Revolutions

■ Mechanization and mass production (- 1980)



Automobile in the 3rd Industrial Revolution

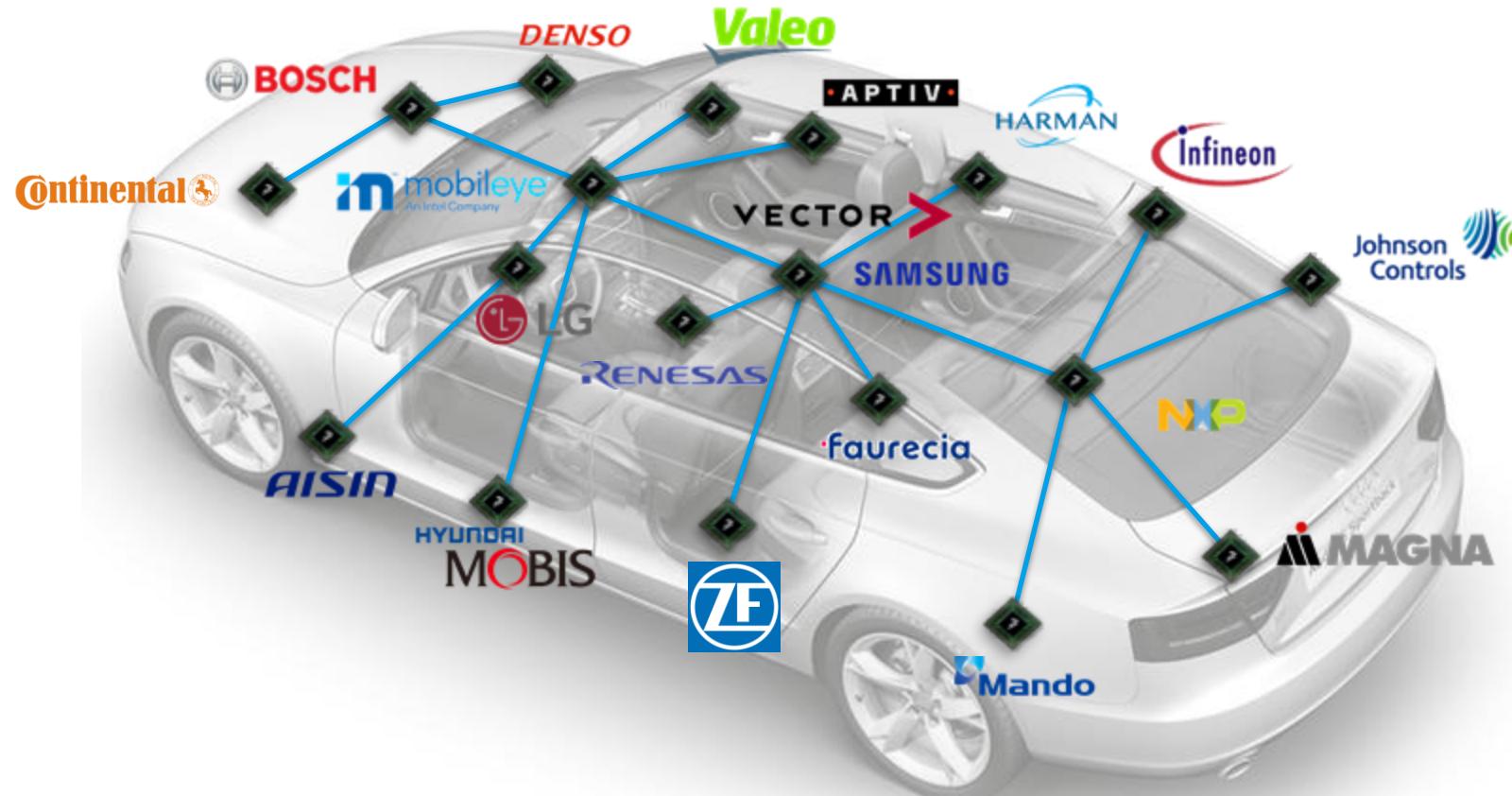
- Electronics and embedded system (1980 – Current)
- From this time on, electronic **sensors** were used extensively.



Current Automotive Industry

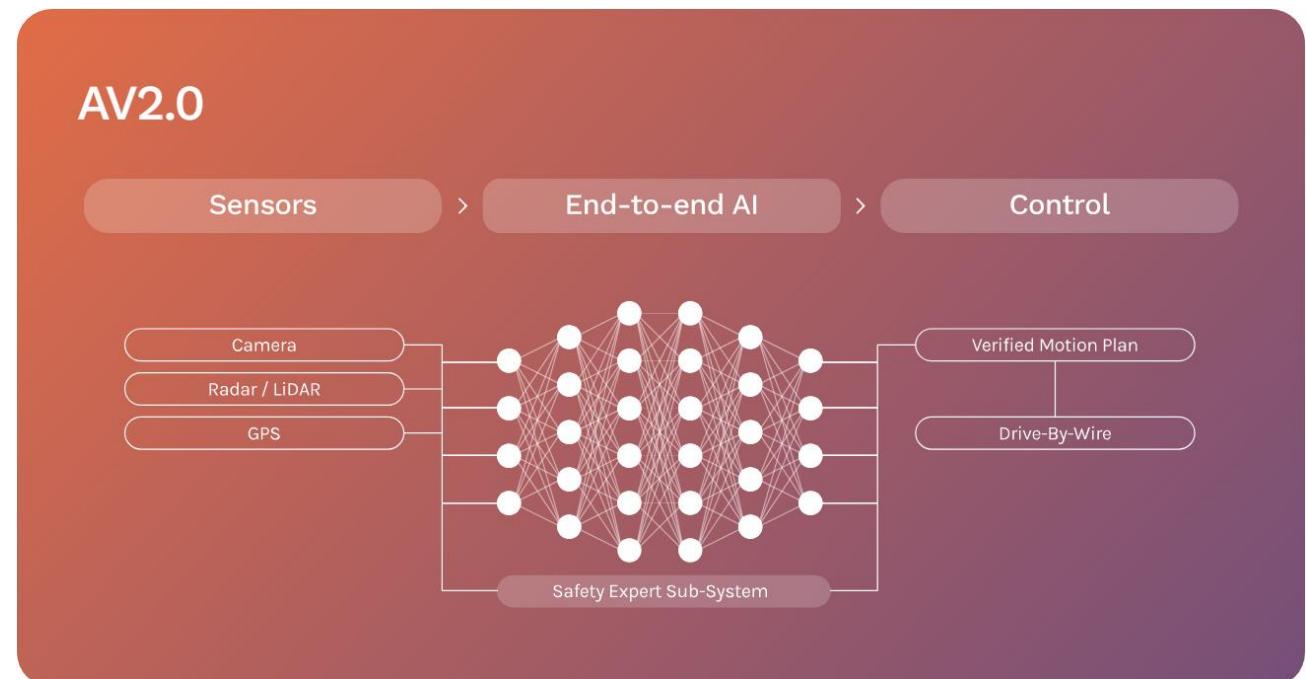
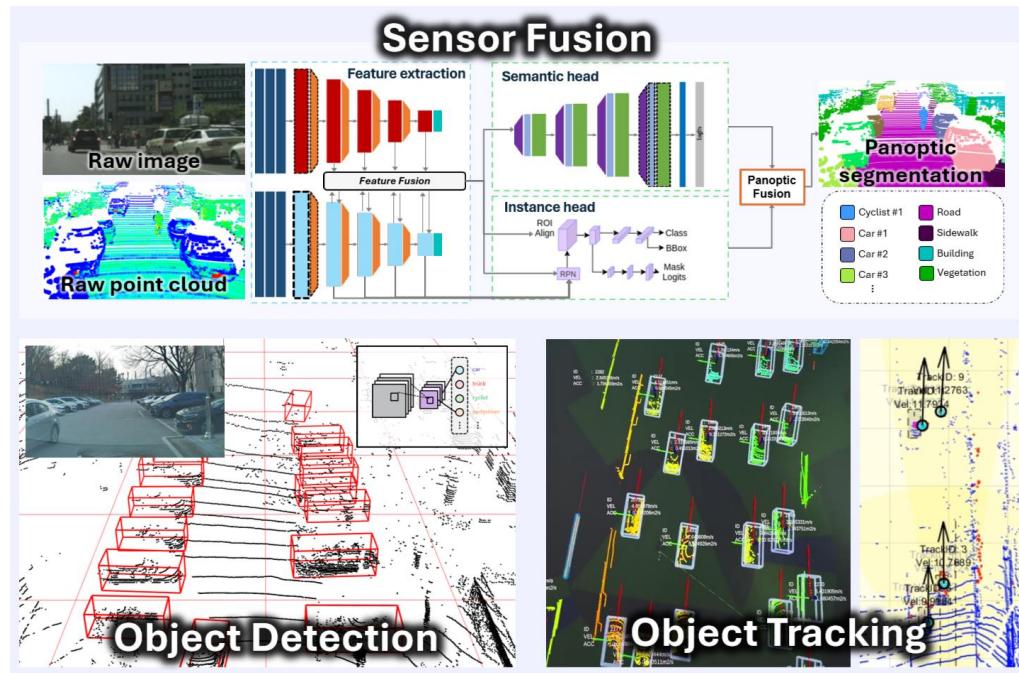
■ OEM – Supplier structure

- ▶ HW-SW tightly coupled.
- ▶ Each supplier develops its own systems (sensors, computers, actuators) and the **SW** that relies on them.



Course Objectives 2

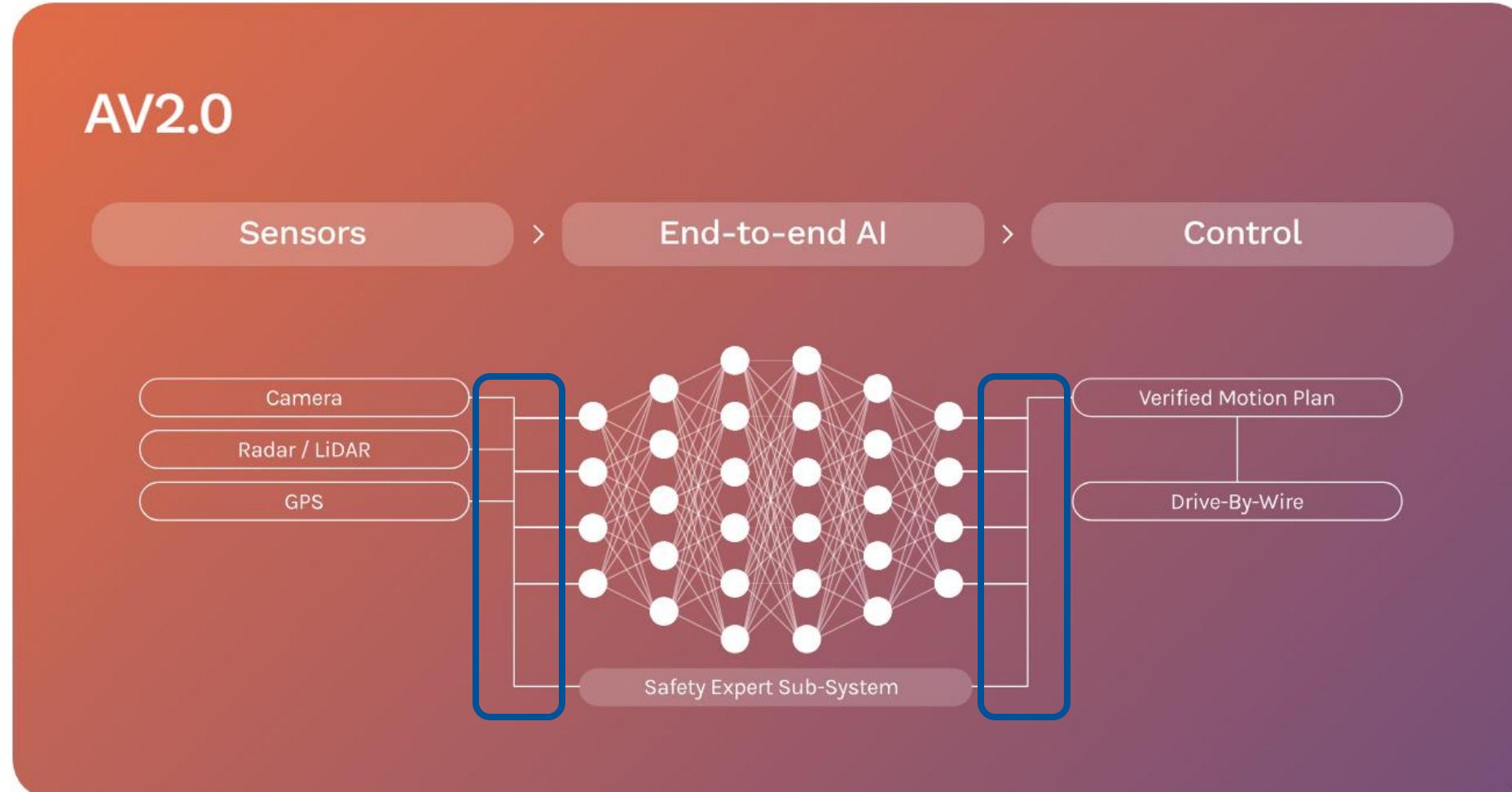
- Learning the principles and types of sensors used in future cars.
- Learning **sensor interface** and **data processing technology**.
- Developing software capabilities through sensor data processing practice.



Applications of AI for Automotive Functions

■ End-to-End Autonomous Driving

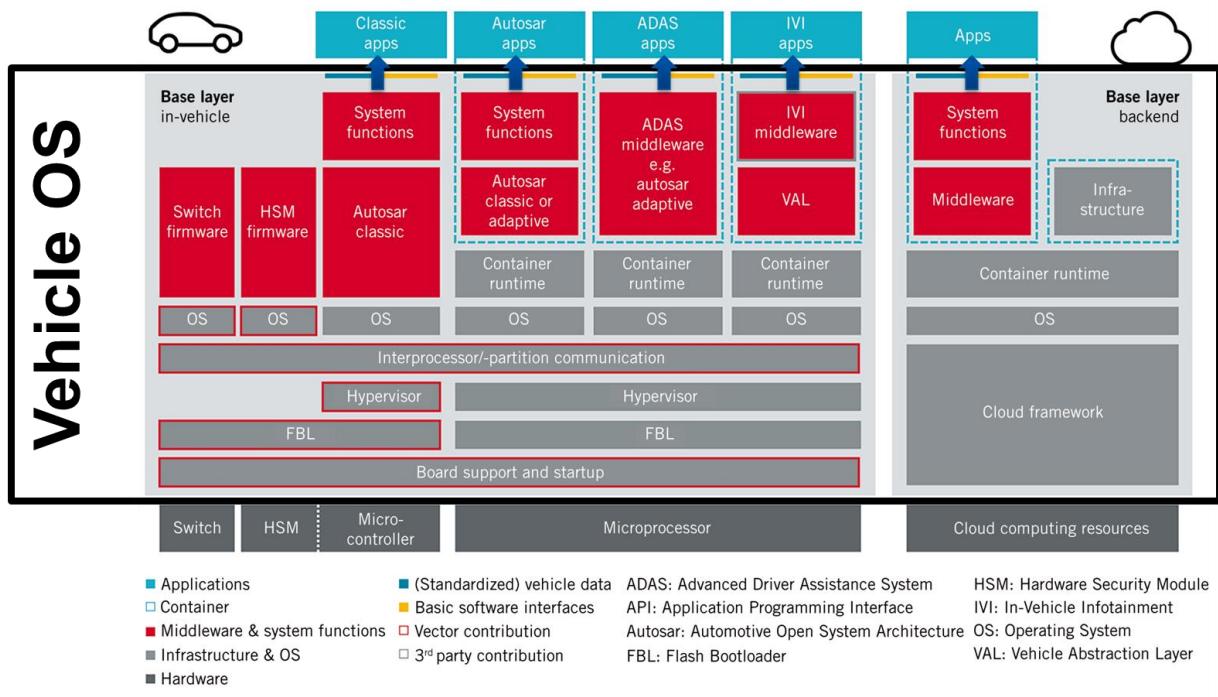
- ▶ Sensor interface and data processing technology are very important!



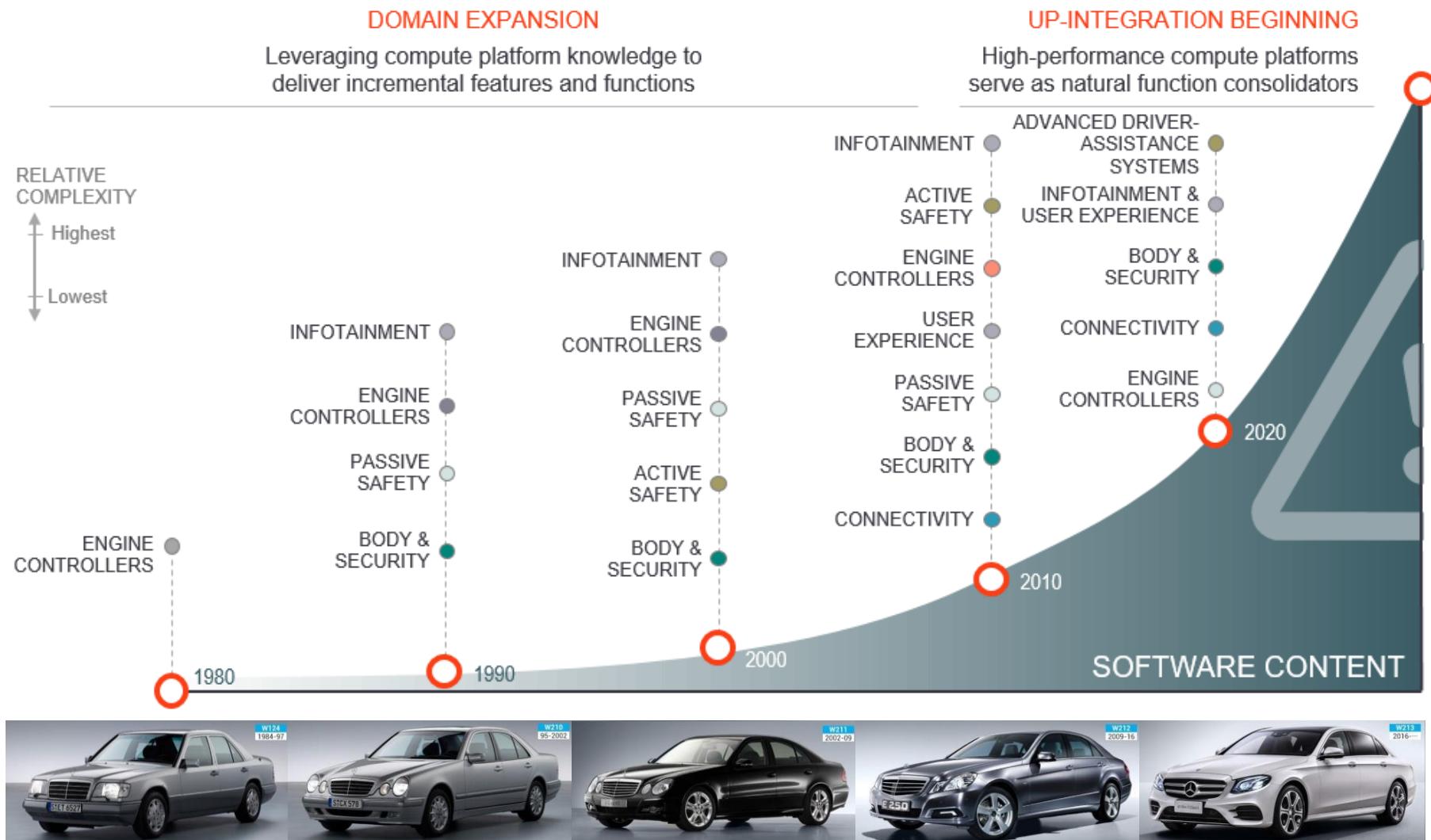
<https://wayve.ai/technology/>

Course Objectives 3

- Learning the principles and types of sensors used in future cars.
 - Learning sensor interface and data processing technology.
 - **Developing software capabilities through sensor data processing practice.**



Software Content in Automobile



The Future of the Automotive SW Industry as seen on Cell Phones (I)

Features defined by
Hardware



The Future of the Automotive SW Industry as seen on Cell Phones (II)

Features defined by
Hardware



Features defined by
Software

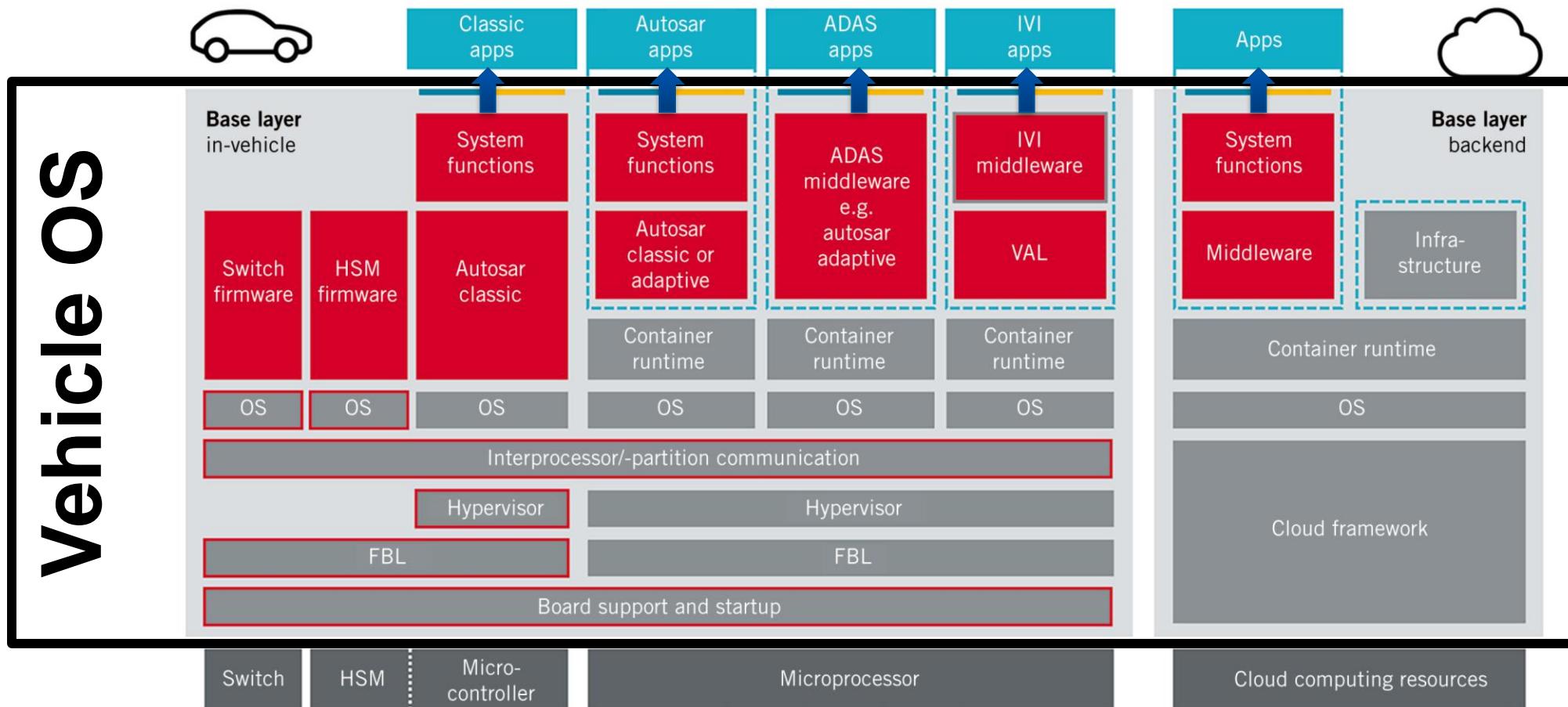


Software Defined Vehicle (SDV)

Software-defined vehicle



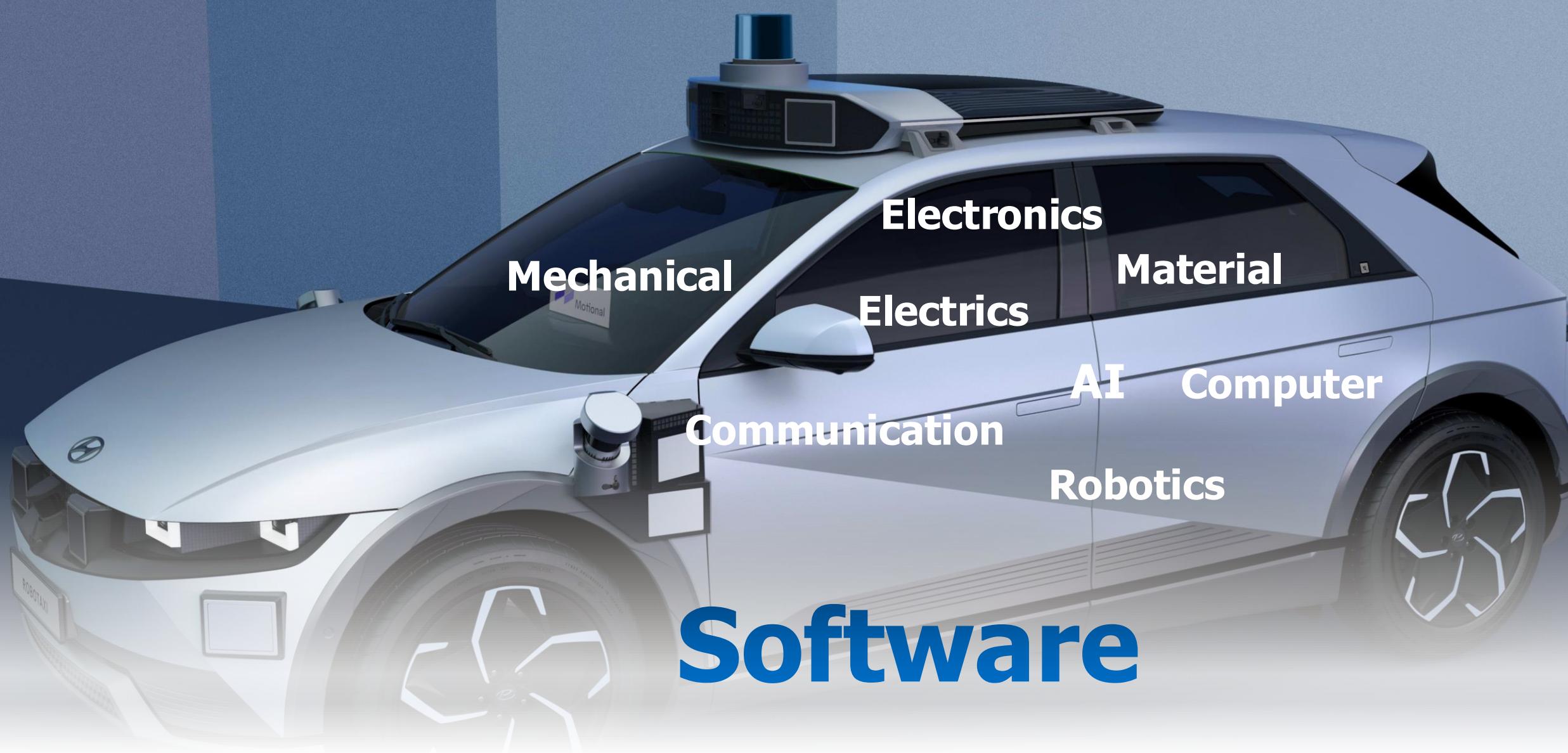
Vehicle OS (Software Platform)



- | | | | |
|---------------------------------|--------------------------------------|--|--------------------------------|
| ■ Applications | ■ (Standardized) vehicle data | ADAS: Advanced Driver Assistance System | HSM: Hardware Security Module |
| □ Container | ■ Basic software interfaces | API: Application Programming Interface | IVI: In-Vehicle Infotainment |
| ■ Middleware & system functions | □ Vector contribution | Autosar: Automotive Open System Architecture | OS: Operating System |
| ■ Infrastructure & OS | □ 3 rd party contribution | FBL: Flash Bootloader | VAL: Vehicle Abstraction Layer |
| ■ Hardware | | | |

FIGURE 2 Architecture and building blocks of the base layer (© Vector Informatik)

Software for Automobile



Course overview

Course Overview

■ 1st part: basic of automotive sensors

- ▶ Learning about the measurement principles of sensors.
- ▶ Learning about different types of automotive sensors.

■ 2nd part: sensors for future automobile

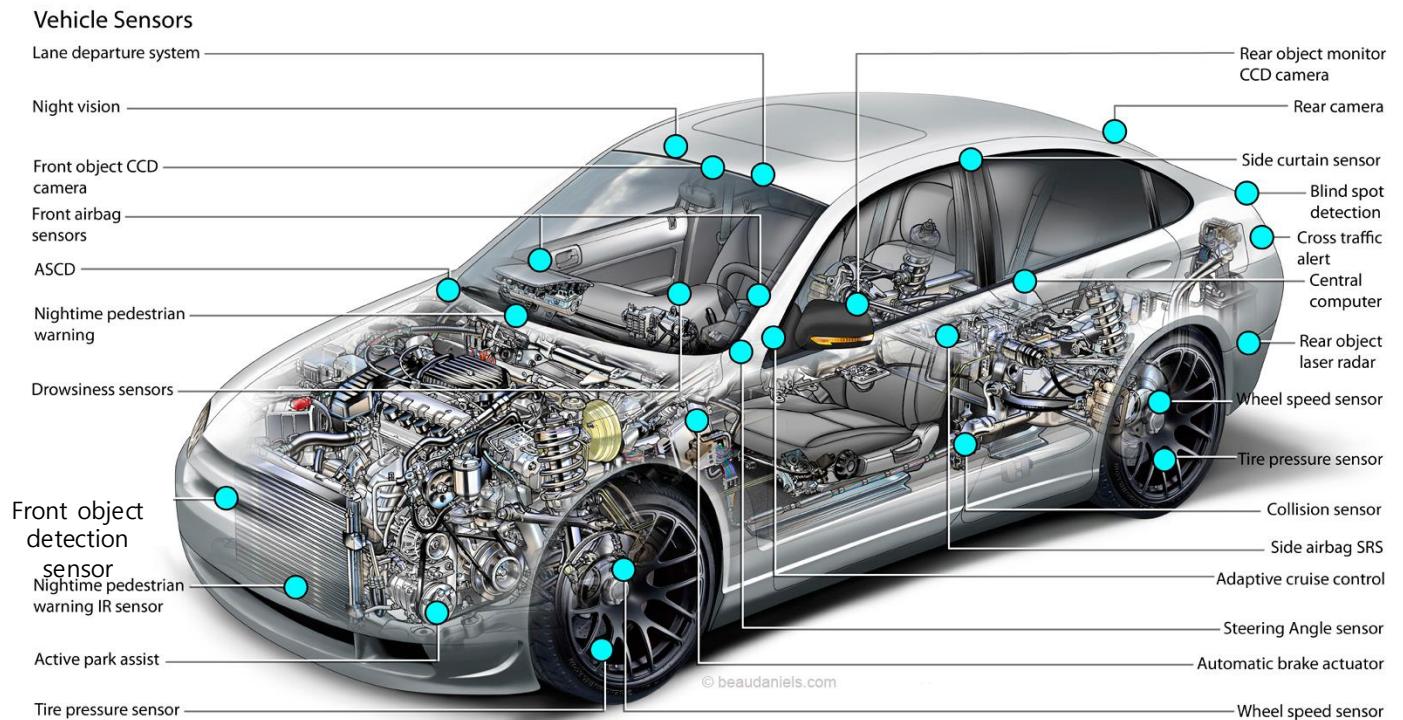
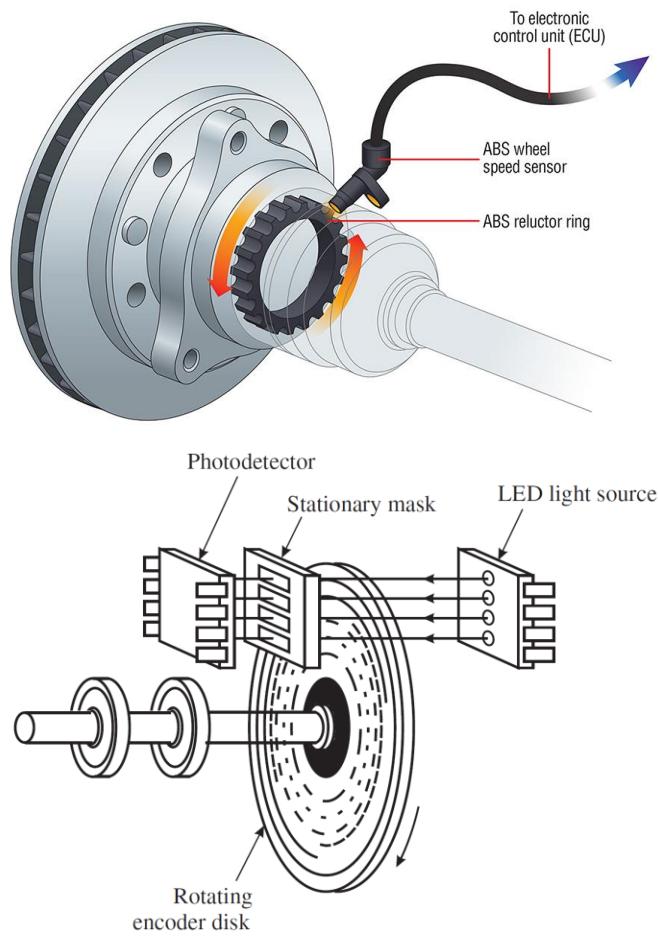
- ▶ Learning about the principles and data of sensors (GPS, IMU, LiDAR, Radar, Camera, etc.) used in future cars.
- ▶ Hands-on training on sensor data interface and processing.

■ 3rd Part: sensor data processing based on Kalman filter

- ▶ Learning the basic theory of Kalman filter (KF) and Extended KF (EKF).
- ▶ Hands-on training on sensor data processing using KF and EKF.

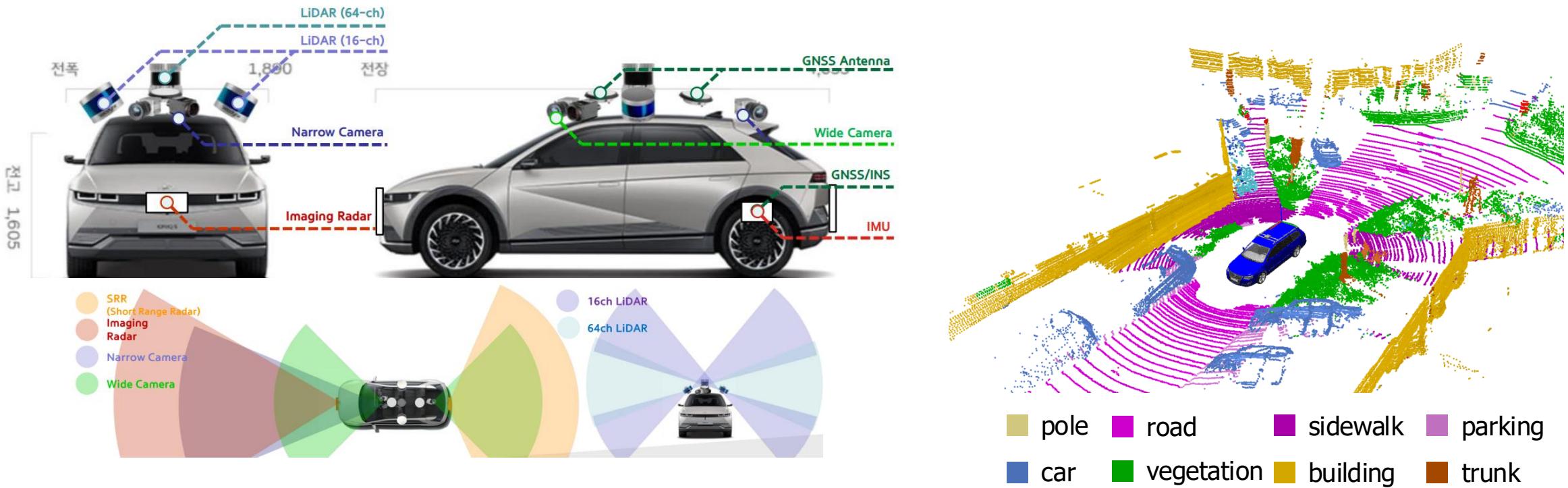
1st Part: Basic of Automotive Sensors

- Learning about the measurement principles of sensors.
- Learning about different types of automotive sensors.



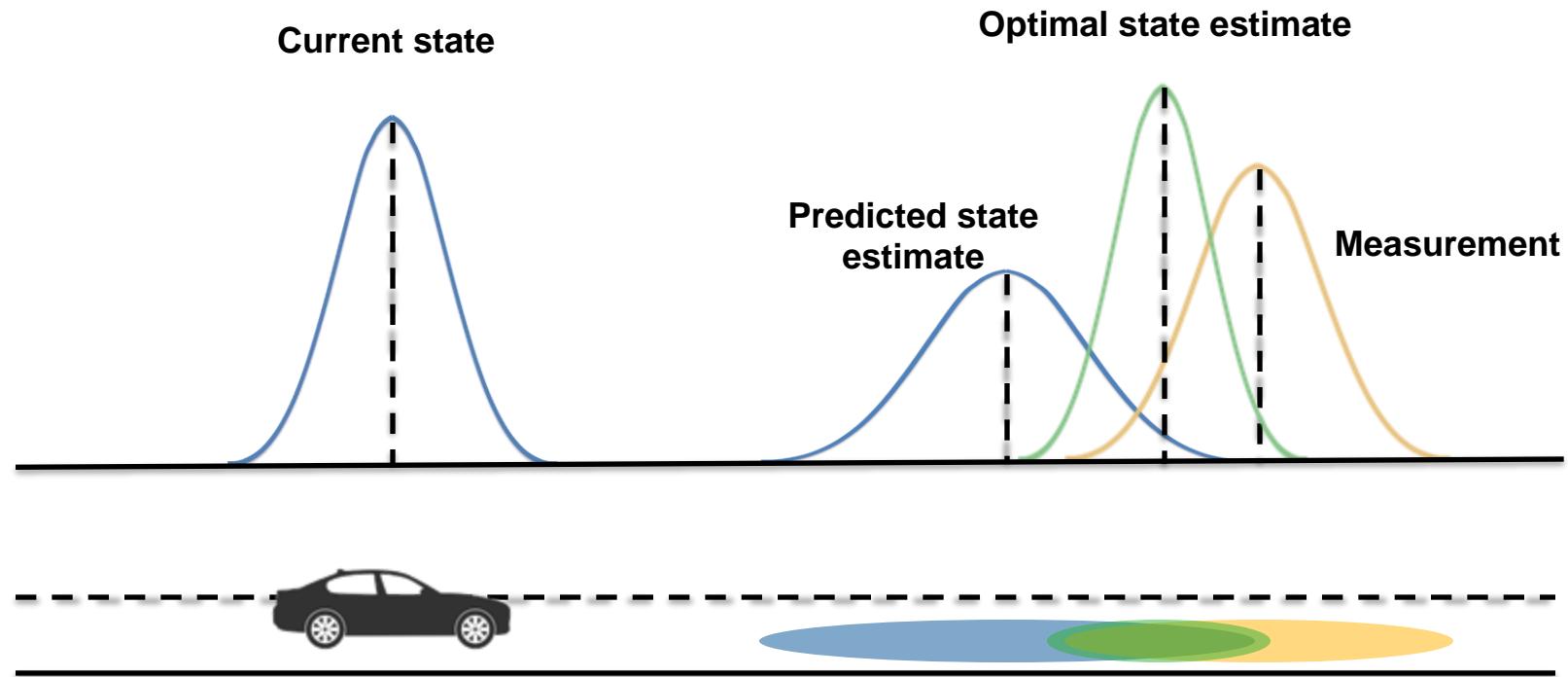
2nd Part: Sensors for Future Automobile

- Learning about the principles and data of sensors (GPS, IMU, LiDAR, Radar, Camera, etc.) used in future cars.
- Hands-on training on sensor data interface and processing.



3rd Part: Sensor Data Processing based on KF

- Learning the basic theory of Kalman filter (KF) and Extended KF (EKF).
- Hands-on training on sensor data processing using KF and EKF.



Schedule & Evaluation

Schedule

Week 1-8

Week	Date	1 st Class	2 nd Class
1	03-04, 03-06	Lecture 0 Introduction - (Practice) MATLAB Onramp	1st part – Lecture 1 Basic of sensors: definition and characteristics
2	03-11, 03-13	1st part – Lecture 2 Sensor principal and type	1st part – Lecture 2 Sensor principal and type
3	03-18, 03-20	2nd part – Lecture 1 Encoder and IMU	2nd part – Practice 1 Noise filtering
4	03-25, 03-27	2nd part – Lecture 2 LiDAR	2nd part – Practice 2 LiDAR point cloud pre-processing (ROI, down sampling, transformation)
5	04-01, 04-03	2nd part – Lecture 3 Radar	2nd part – Practice 3 Radar point cloud pre-processing (kd-tree, noise filtering, clustering)
6	04-08, 04-10	2nd part – Lecture 4 GPS	2nd part – Practice 4 Geodetic coordinate conversion and tile system
7	04-15, 04-17	2nd part – Lecture 5 Calibration (sensor fusion)	2nd part – Practice 5 Point cloud projection on camera image
8	04-22, 04-24	Mid-term project and/or exam	Mid-term project and/or exam

Schedule

■ Week 9-16

Week	Date	1 st Class	2 nd Class
9	04-29, 05-01	3 rd part – Lecture 0 Introduction to Kalman filter	3 rd part – Lecture 1 Linear system theory
10	05-06, 05-08	3 rd part – Practice 1 Linear algebra Onramp	3 rd part – Practice 2 System modeling and simulation
11	05-13, 05-15	3 rd part – Lecture 2 Probability theory 3 rd part – Lecture 3 Least square estimation	3 rd part – Practice 3 Least square
12	05-20, 05-22	3 rd part – Lecture 4 Recursive Least square estimation	3 rd part – Practice 4 Recursive least square
13	05-27, 05-29	3 rd part – Lecture 5 Propagation of states and covariances	3 rd part – Practice 5 State covariance propagation
14	06-03, 06-05	3 rd part – Lecture 6 The discrete-time Kalman filter	3 rd part – Practice 6 1d Kalman filter, 2d Kalman filter
15	06-10, 06-12	3 rd part – Lecture 7 Extended Kalman filter	3 rd part – Practice 7 Extended Kalman filter
16	06-17, 06-19	Final project and/or exam	Final project and/or exam

Evaluation



10%: attendance



30%: assignment



30%: mid-term project and/or exam.



30%: final project and/or exam.

Assignment



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Practice

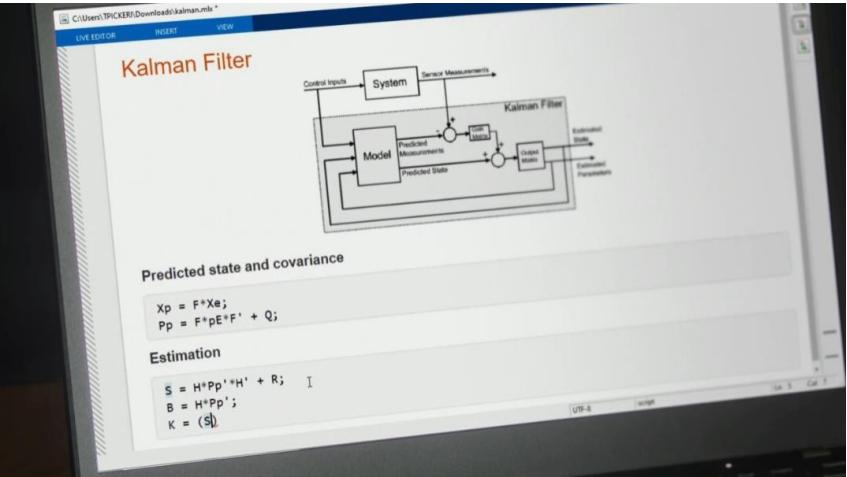
■ The class will

- ▶ Learn the Theory + Coding.

■ Students must...

- ▶ Prepare your **laptop, tablet**, or anything else you can write code in MATLAB.

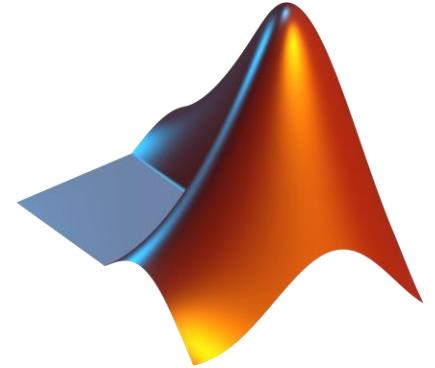
- You can use MATLAB on a cellphone “MATLAB Mobile”, but we recommend you prepare a laptop or tablet.



MATLAB Onramp

■ MATLAB?

- ▶ MATLAB is a programming and numeric computing platform used by millions of engineers and scientists to analyze data, develop algorithms, and create models.



■ MATLAB Onramp

- ▶ MATLAB Onramp is a course that teaches you the basics of using MATLAB.
- ▶ Onramp consists of exercises to answer the questions correctly by entering commands directly and video lecture.

MATLAB



MATLAB Onramp

15개 모듈 | 2시간 | 언어

MATLAB의 기본 사항을 빠르게 학습할 수 있습니다.

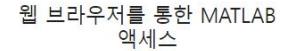
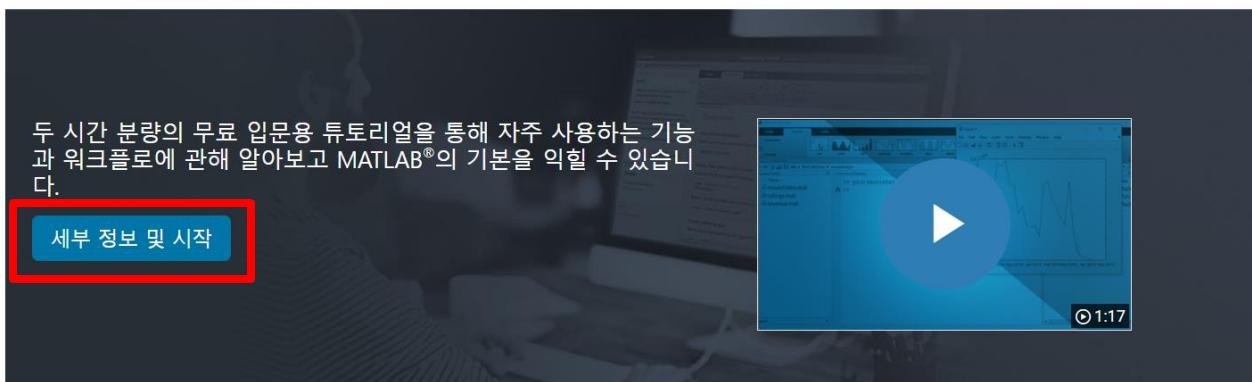
MATLAB Onramp

Start Onramp on matlab web browser.

▶ <https://kr.mathworks.com/learn/tutorials/matlab-onramp.html>

The screenshot shows the MathWorks website with a blue header bar. The main content area features a large image of a person working on a computer, with a red box highlighting the '세부 정보 및 시작' (Details and Start) button. Below the image is a video thumbnail with a play button and a duration of 1:17. Navigation links at the bottom include '교육 개요', '교육과정 찾기', '자격증 취득', '방문 교육', '전문 교육', and '더 보기'.

MATLAB Onramp



웹 브라우저를 통한 MATLAB
액세스



홍미로운 비디오 튜토리얼



자동 채점 및 피드백이 제공되
는 실습 예제



한국어, 영어, 중국어, 스페인어,
일본어로 학습 가능

The screenshot shows the MATLAB Onramp course page. At the top, there is a 'Course Overview' section with a progress bar at 100%. Below it is a 'Commands' section with a progress bar at 50%. A sidebar on the left lists course modules: MATLAB Desktop and Editor, Vectors and Matrices, Indexing into and Modifying Arrays, Array Calculations, Calling Functions, Obtaining Help, Plotting Data, Importing Data, Logical Arrays, Programming, Final Project, and Conclusion. A right sidebar shows course details: 평균: 자기 주도형, 길이: 2시간, 언어: English (영어). It also includes a profile picture of Renee Bach, MathWorks.

MATLAB Onramp

■ You can submit the practice by entering the appropriate code in the command line or script for each task.

The screenshot shows the MATLAB Onramp interface. On the left, there is a task pane with sections for '작업 1', '작업 2', '작업 3', and '작업 4'. Under '작업 1', there is a code editor with the following code:

```
x = [1 2 3];
y = x + 2;
y =
    3     4     5
```

Below the code editor is a box containing instructions:

작업
Add 1 to each element of v1 and store the result in a variable named r.

Buttons at the bottom of this box include '힌트' (Hint), '정답 보기' (View Answer), '초기화' (Reset), '제출하기' (Submit) which is highlighted with a red box, and '다음 작업' (Next Task).

The main workspace on the right contains the following content:

- Toolbar:** Includes tabs for Home, Live Editor, View, and various execution and section management buttons.
- Current File:** arrayops.mlx
- Title Bar:** Performing Array Operations on Vectors
- Instructions:** Instructions are in the task pane to the left. Complete and submit each task one at a time.
- Code Editor:** Shows the following code:

```
1
2
3
4
load datafile
density = data(:,2);
v1 = data(:,3)
v2 = data(:,4)
```
- Task 1:** A box containing the code:

```
r = v1 + 1
```
- Task 2:** An empty box for the next task.
- Output Window:** Displays the results of the operations:

```
v1 = 7x1
4.0753
6.6678
1.5177
3.6375
4.7243
9.0698
5.3002

v2 = 7x1
0.5000
2.1328
3.6852
8.5389
10.1570
2.8739
4.4508

r = 7x1
5.0753
7.6678
2.5177
4.6375
5.7243
10.0698
6.3002
```

Assignment

■ Please submit your MATLAB Onramp certificate.

- ▶ Submit by 3/10 (One week).

■ How to turn in assignment.

- ▶ Log in on [HY-ON] → Enter [차량센서] class → Click [과제 및 평가: Assignment and Evaluation]
→ Click [1st Week Assignment - MATLAB Onramp] → Upload one PDF file.



2024년 1학기

과제 검색

마감순으로 보기 유형별로 보기

과제

1st Week Assignment - MATLAB Onramp
시작 3월 4일 pm 2:00 | 마감 3월 10일 오후 11:59 | -/10점

2024년 1학기

▶ 홈

사용자 및 그룹

수업 계획서

게시판

주차학습

과제 및 평가

강의자료실

출결현황

오프라인출결

성적



**THANK YOU
FOR YOUR ATTENTION**



HANYANG UNIVERSITY

