

Linear Algebra

Course Introduction

Automotive Intelligence Lab.



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Course Information

■ Class

- ▶ Lecture & Exercise

■ Communication with LMS

- ▶ Announcements
- ▶ Lecture notes
- ▶ Assignments

■ Prerequisites

- ▶ Computer(laptop, tablet, ...) to write code on MATLAB.
- ▶ Basic algebra and geometry.
 - High-school level
- ▶ Basic programming skills.
 - Freshman level

■ Textbook

- ▶ We will provide lecture slides.

■ Reference

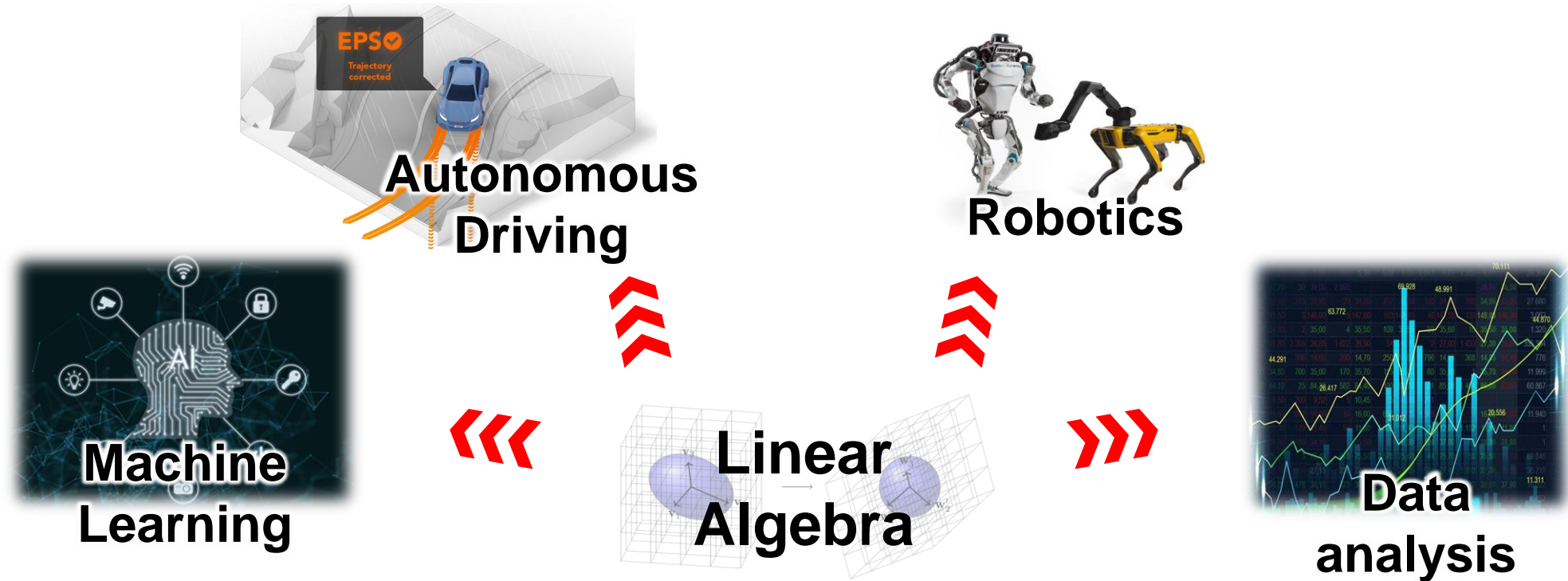
- ▶ “Introduction to Linear Algebra” – Gilbert Strang
- ▶ 3Blue1Brown (Youtube)
- ▶ Angelo’s math notes (공돌이의 수학노트)
- ▶ Matlab

Course background

History of Linear Algebra

- In the 17th century in the West and much earlier in China, **matrices** were just used to provide a compact notation for storing sets of numbers.
- In the 20th century, **matrices** and **vectors** were used for **multivariate mathematics** including calculus, differential equations, physics, and economics.
- But most people didn't need to care about matrices until fairly recently.
 - ▶ Here's the thing: **computers** are extremely efficient at working with matrices.
 - ▶ And so, modern **computing** gave rise to modern linear algebra.

Why Learn Linear Algebra



Linear algebra is utilized in various fields for machine learning, autonomous driving, robotics, and others.

*To understand how the algorithms work and to develop them, you should learn **Linear Algebra** !*

Trend 1: Software Defined Vehicle (SDV)

- **SDV (Software-Defined Vehicle)** refers to vehicles whose functions and services are defined primarily by software.
- **Continuous feature improvements** are possible throughout the vehicle's lifespan via **software updates**.

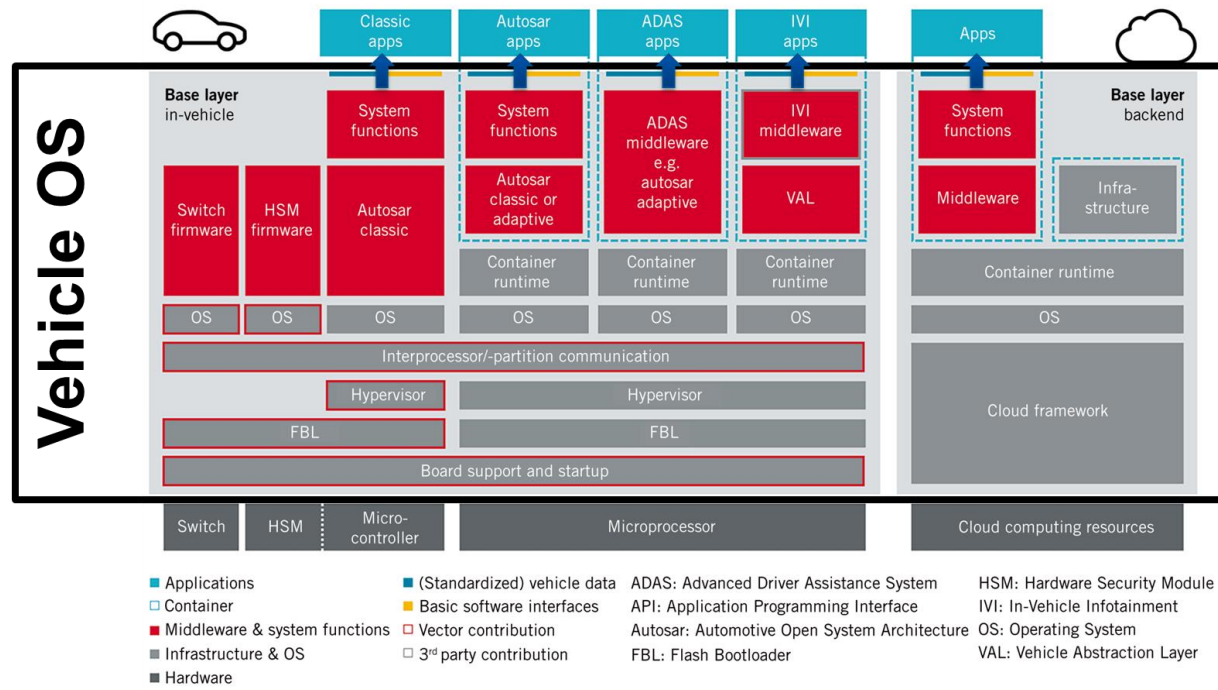


FIGURE 2 Architecture and building blocks of the base layer (© Vector Informatik)



Automobile in the 1st and 2nd Industrial Revolutions

■ Mechanization and mass production (- 1980)



Automobile in the 3rd Industrial Revolution

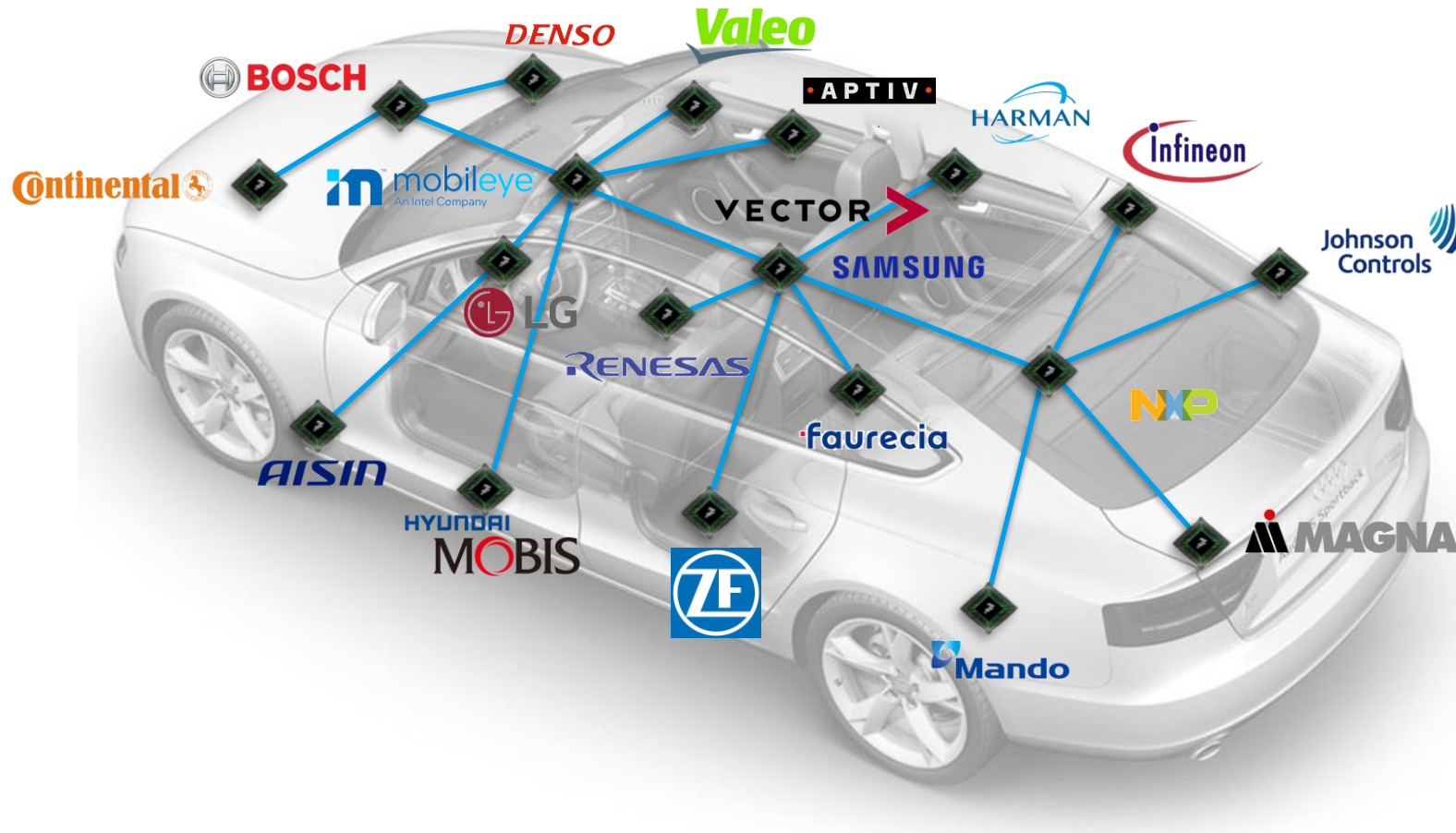
- Electronics and embedded system (1980 –)
- From this time on, **software** were applied to the automotive functions.



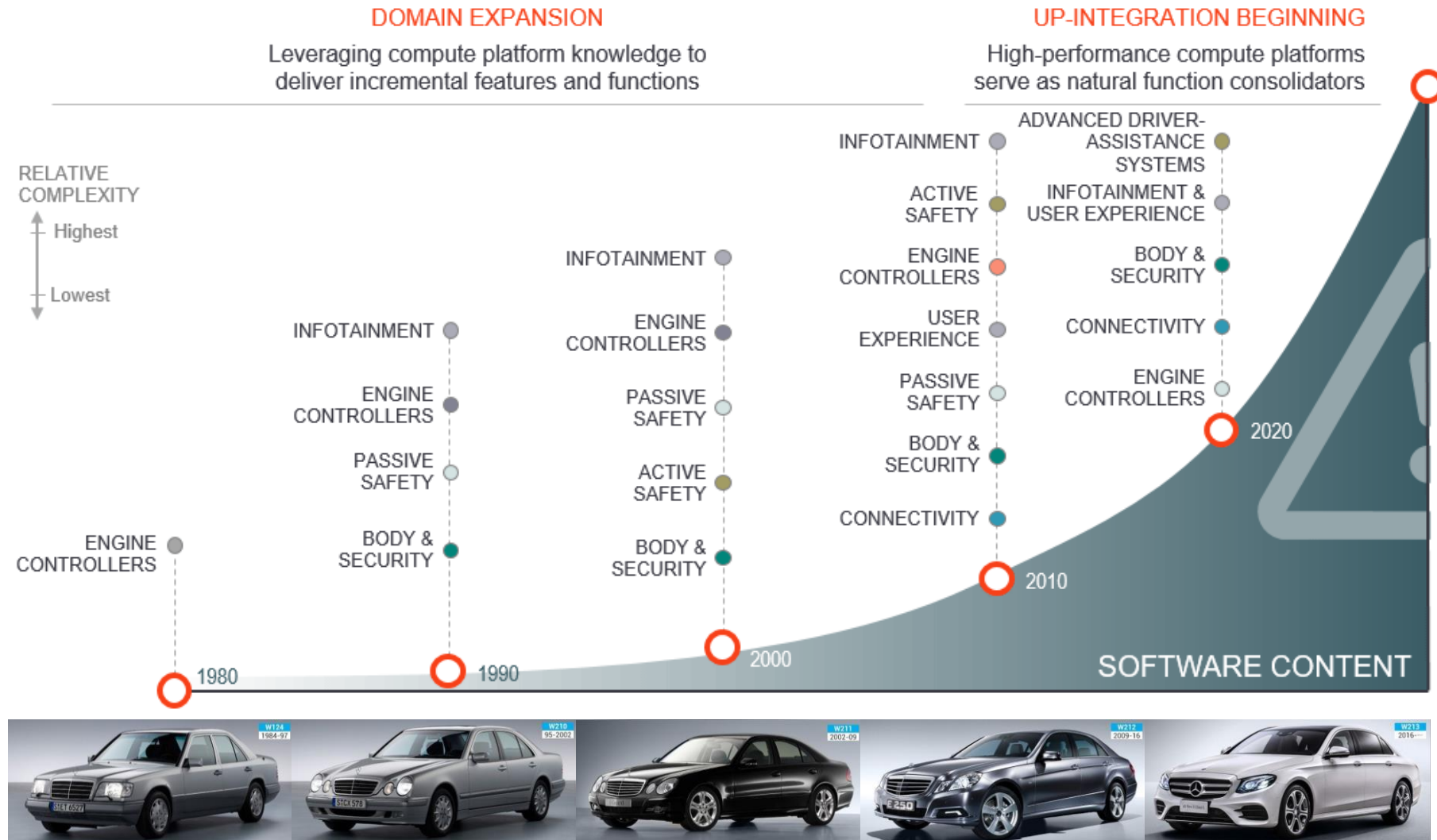
Current Automotive Industry

■ OEM – Supplier structure

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

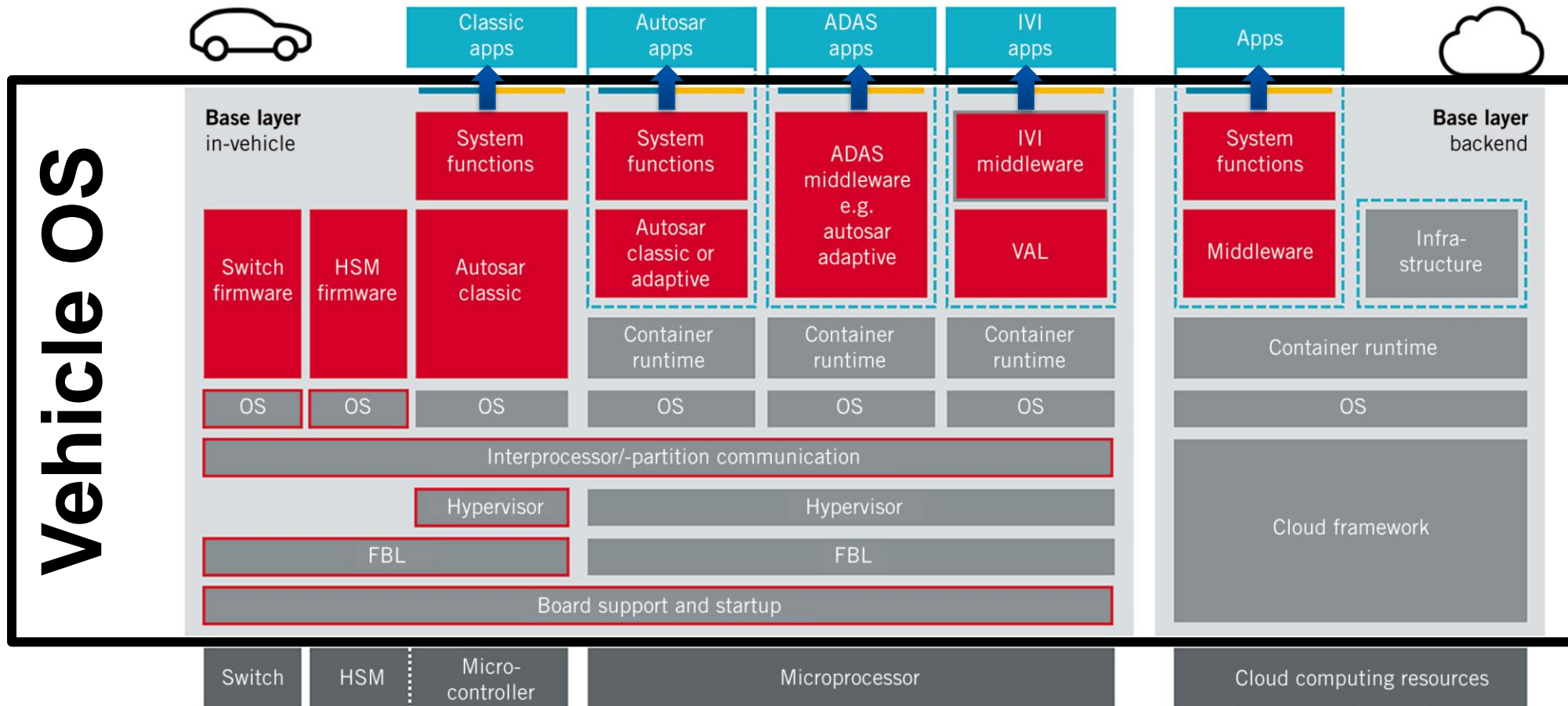


Software Content in Automobile



[출처: Aptiv]

Vehicle OS (Software Platform)



■ Applications

□ Container

■ Middleware & system functions

■ Infrastructure & OS

■ Hardware

■ (Standardized) vehicle data

■ Basic software interfaces

□ Vector contribution

□ 3rd party contribution

ADAS: Advanced Driver Assistance System

API: Application Programming Interface

Autosar: Automotive Open System Architecture

FBL: Flash Bootloader

HSM: Hardware Security Module

IVI: In-Vehicle Infotainment

OS: Operating System

VAL: Vehicle Abstraction Layer

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

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



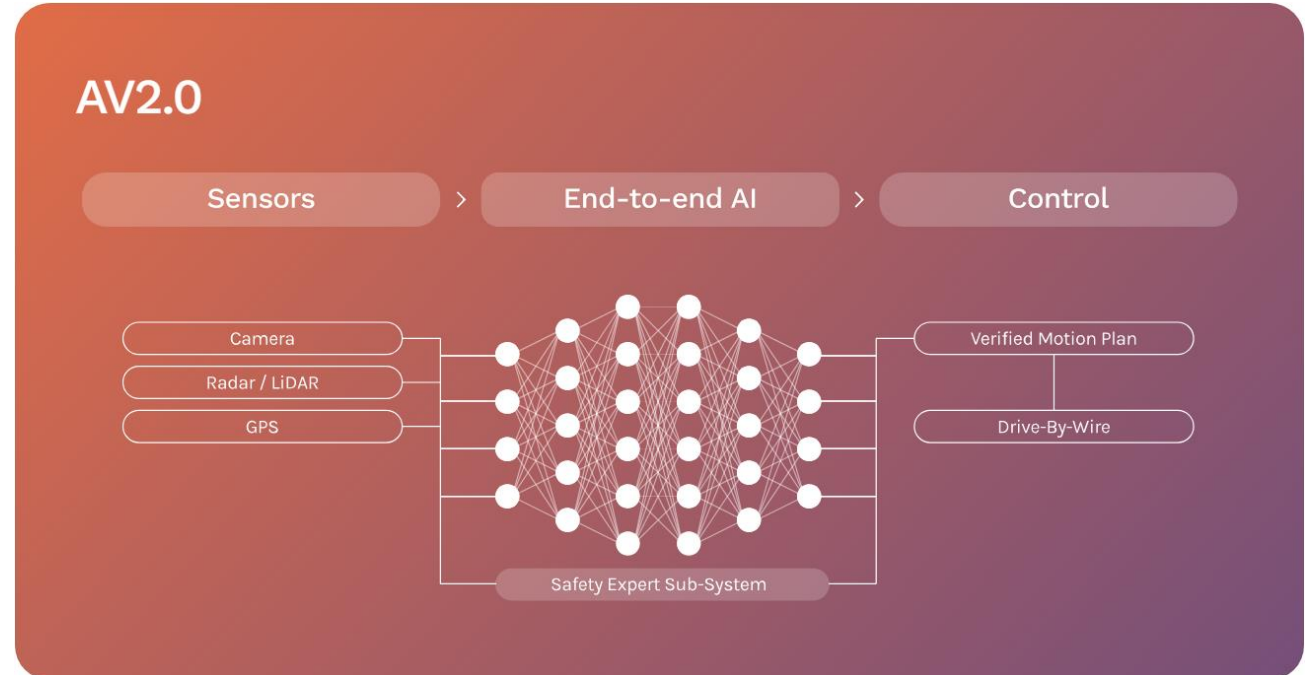
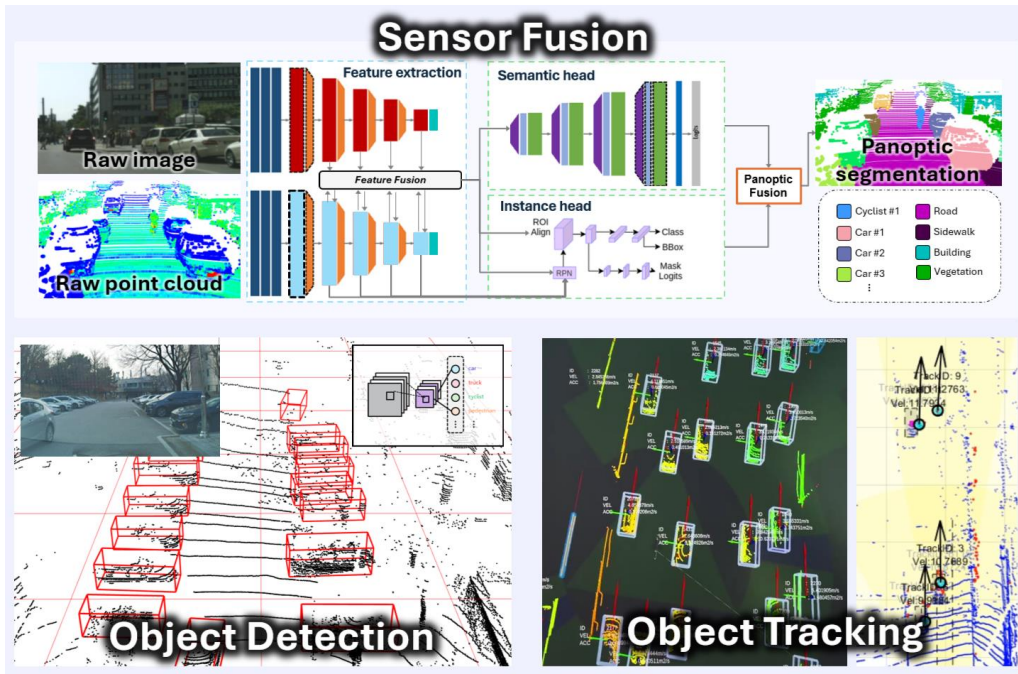
Software for Automobile



Software

Trend 2: AI for Automobile

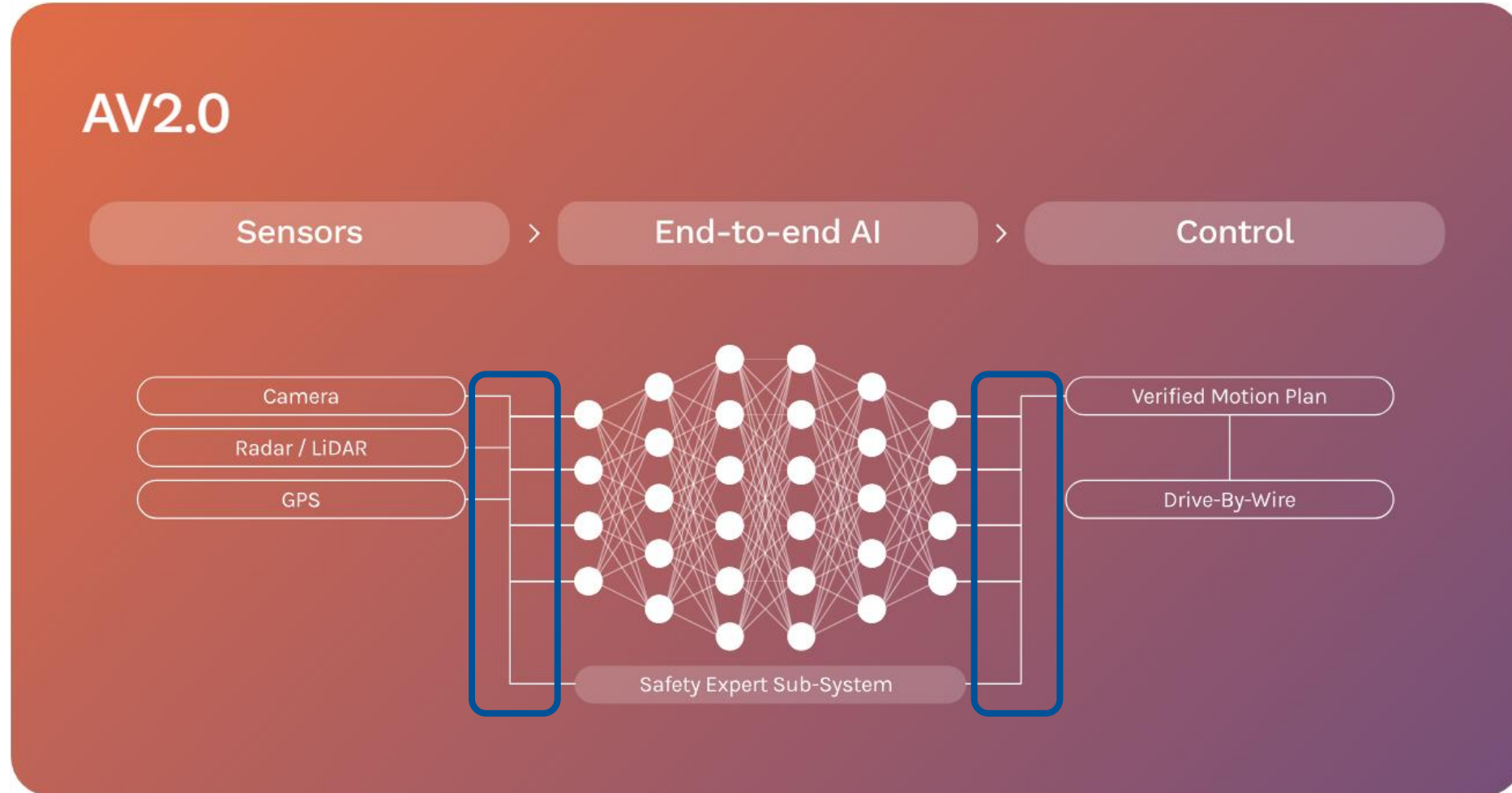
■ AI is being used for many functions in automobiles!



Applications of AI for Automotive Functions

■ End-to-End AI Autonomous Driving

- ▶ Data processing technology is essential!



Course objectives

Course Objectives

- Understand linear algebra as an **engineering tool**, **not as mathematics**.
- Understand linear algebra through **programming** **rather than solving problems by hand**.
- Actively utilizes **geometric visual examples** through programming to aid understanding.
- Improve your **programming skills** through **real world problems**.

Traditional and Modern Linear Algebra

■ Traditional and Modern

Traditional

- Abstract.
- Learned through proofs and equations.
- Emphasizes proofs and abstract concepts, often with little relevance to practical applications or implementations.

Modern

- Computational.
- Learned through code and applications.
- Emphasizes geometric intuition and implementation of linear algebra concepts in practical applications.

Mathematical Proofs vs. Visualization and Examples

■ The two ways to understand math

▶ Mathematical proofs

- A proof in mathematics is a sequence of statements showing that a set of assumptions leads to a logical conclusion.
- Rigor but rarely intuition.

▶ Visualizations and examples

- Clearly written explanations, diagrams, and numerical examples help you gain intuition for concepts and operations in linear algebra.
- More intuition than mathematical proofs.

■ This class will focus on **visualizations and examples** through MATLAB.

This class will focus on

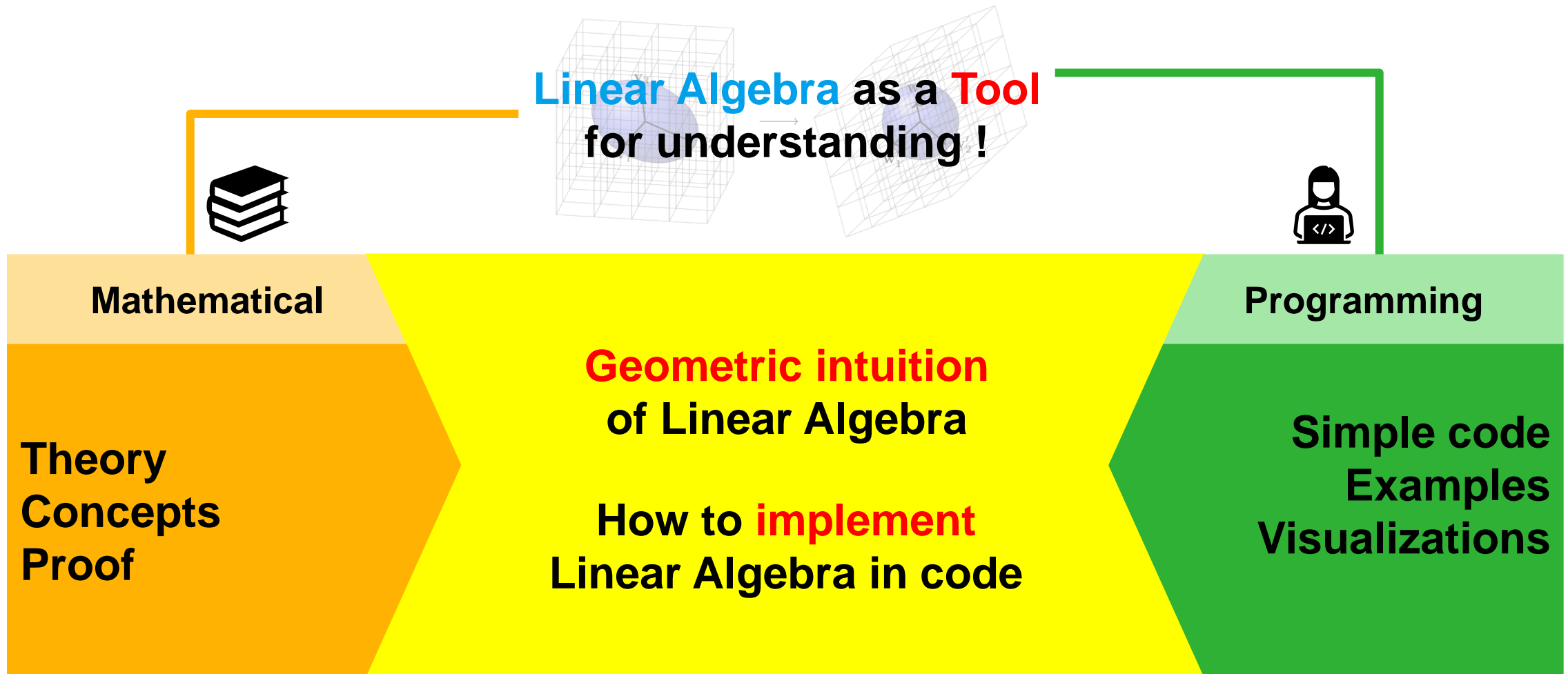
Modern

- Computational.
- Learned through code and applications.
- Emphasizes geometric intuition and implementation of linear algebra concepts in practical applications.

Especially here!

Linear Algebra as a **Tool**
for understanding
data, statistics, deep
learning, image
processing, etc.!

Instructional approach



Proof based on Matlab

```
% Creating a and b matrix with 4 by 4
```

```
a = rand(4)
```

```
b = rand(4)
```

```
% proof  $a*b$  is not same as  $b*a$ 
```

```
 $a*b - b*a$ 
```

Course schedule and evaluation

Schedule (I)

■ Week 1 – 8:

Week	Date	1 st Class	2 nd Class
1	03-05, 03-07	Orientation (lecture) - Introduction of objective, evaluation, and class - Introduction of MATLAB	Chapter 1 Vector, part 1 : vectors and basic operations
2	03-12, 03-14	Chapter 1 Vector, part 1 : vectors and basic operations	Chapter 2 Vector, part 2 : expand concept of vectors
3	03-19, 03-21	Chapter 2 Vector, part 2 : expand concept of vectors	Chapter 3 Vector applications
4	03-26, 03-28	Chapter 4 Matrices, part 1 : matrices and basic operations	Chapter 4 Matrices, part 1 : matrices and basic operations
5	04-02, 04-04	Chapter 5 Matrices, part 2 : expand concept of matrices	Chapter 5 Matrices, part 2 : expand concept of matrices
6	04-09, 04-11	Chapter 5 Matrices, part 2 : expand concept of matrices	Chapter 6 Matrix applications
7	04-16, 04-18	Chapter 7 Matrix inverse	Chapter 7 Matrix inverse
8	04-23, 04-25	Midterm Exam	Midterm Exam

Schedule (II)

■ Week 9 – 16:

Week	Date	1 st Class	2 nd Class
9	04-30, 05-02	Chapter 8 Orthogonal Matrices and QR Decomposition	Chapter 8 Orthogonal Matrices and QR Decomposition
10	05-07, 05-09	Chapter 9 Row reduction and LU Decomposition	Chapter 9 Row reduction and LU Decomposition
11	05-14, 05-16	Chapter 10 General Linear Models and Least Squares	Chapter 11 Least Squares applications
12	05-21, 05-23	Chapter 11 Least Squares applications	Chapter 12 Eigen Decomposition
13	05-28, 05-30	Chapter 12 Eigen Decomposition	Chapter 13 MATLAB Onramp – Linear Algebra
14	06-04, 06-06	Chapter 14 Singular value Decomposition	-
15	06-11, 06-13	Chapter 14 Singular value Decomposition	Chapter 15 Eigen Decomposition and SVD applications
16	06-18, 06-20	Final Exam	Final Exam

Evaluation



10%: attendance



30%: assignment



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



30%: final project and/or exam.

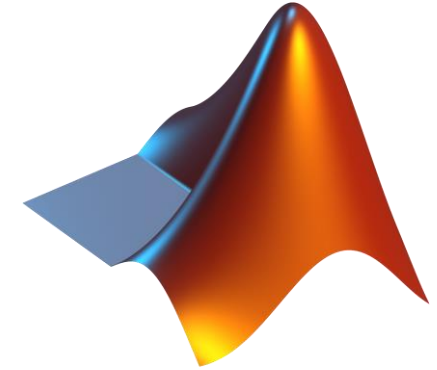
Assignment



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.

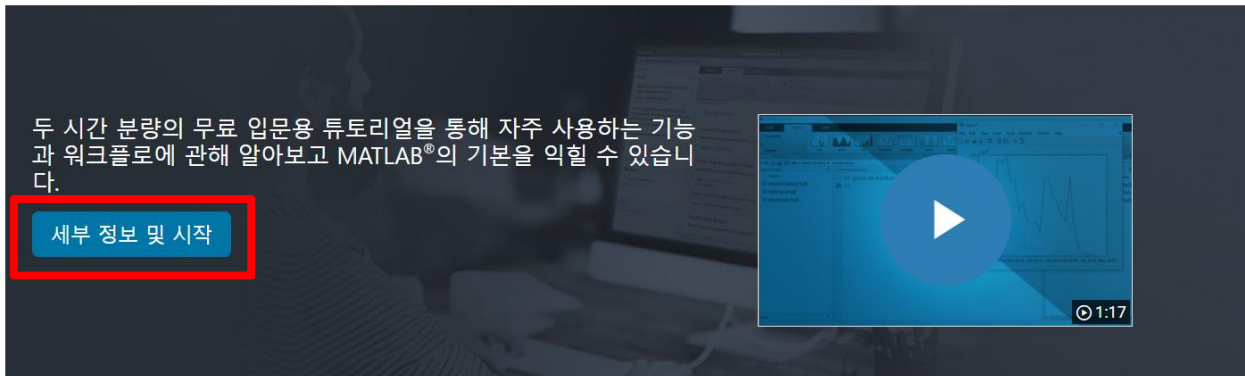
MATLAB Onramp

■ Start Onramp on matlab web browser

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



MATLAB Onramp

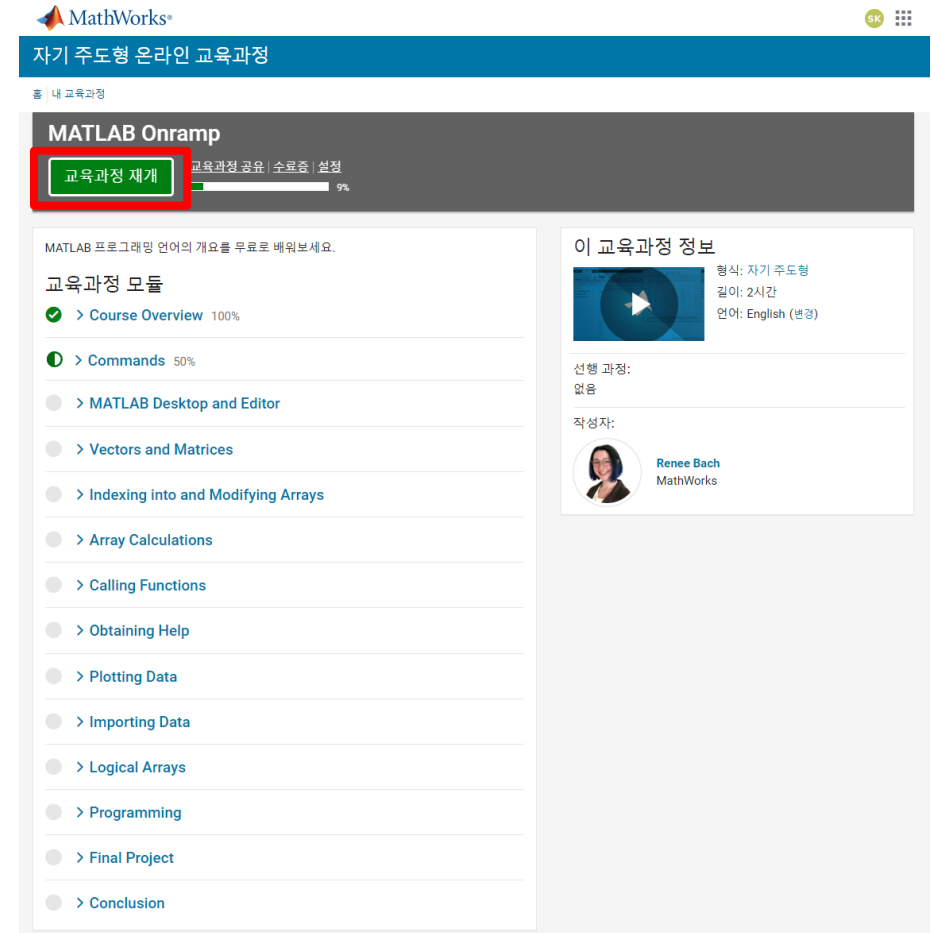


웹 브라우저를 통한 MATLAB 액세스

흥미로운 비디오 튜토리얼

자동 채점 및 피드백이 제공되는 실습 예제

한국어, 영어, 중국어, 스페인어, 일본어로 학습 가능



MATLAB Onramp

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

작업 1

MATLAB is designed to work naturally with arrays. For example, you can add a scalar value to all the elements of an array.

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

작업

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

힌트 | 정답 보기 | 초기화

제출하기 다음 작업

테스트 결과: **정답입니다!**

- ✓ Did you make a variable named `r`?
- ✓ Did you add 1 to each element of `r`?

홈

라이브 편집기

보기

텍스트

일반

코딩

리팩터링

섹션 나누기

실행 및 진행

실행

스텝

중지

코드

컨트롤

작업

리팩터링

섹션 나누기

실행 및 진행

실행

스텝

중지

arrayops.mlx

Performing Array Operations on Vectors

Instructions are in the task pane to the left. Complete and submit each task one at a time.

This code sets up the interaction.

```
1 load datafile
2 density = data(:,2);
3 v1 = data(:,3)
4 v2 = data(:,4)
```

Task 1

5 `r = v1 + 1`

Task 2

6

7

v1 = 7×1

```
4.0753
6.6678
1.5177
3.6375
4.7243
9.0698
5.3002
```

v2 = 7×1

```
0.5000
2.1328
3.6852
8.5389
10.1570
2.8739
4.4508
```

r = 7×1

```
5.0753
7.6678
2.5177
4.6375
5.7243
10.0698
6.3002
```



**THANK YOU
FOR YOUR ATTENTION**