

# 자율주행 산업 및 직무 강연

- Introduction to Autonomous Driving -

Autonomous Driving Research Engineer

April 21, 2021

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- **Definition of Autonomous Driving**
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# **Why Autonomous Driving?**

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# Why Autonomous Driving?

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- Do we really need autonomous driving ?
  - Convenience



# Why Autonomous Driving?

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- Do we really need autonomous driving ?
  - Safety



# Definition of Autonomous Driving

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# Definition of Autonomous Driving

## ▪ Classification by Technical Level

- by SAE (국제자동차기술자협회)



### SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	<p>You <u>are</u> driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering</p> <p>You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety</p>			<p>You <u>are not</u> driving when these automated driving features are engaged – even if you are seated in “the driver’s seat”</p> <p>When the feature requests, you must drive</p> <p>These automated driving features will not require you to take over driving</p>		
What do these features do?	<p>These are driver support features</p> <p>These features are limited to providing warnings and momentary assistance</p> <p>These features provide steering OR brake/acceleration support to the driver</p> <p>These features provide steering AND brake/acceleration support to the driver</p>			<p>These are automated driving features</p> <p>These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met</p> <p>This feature can drive the vehicle under all conditions</p>		
Example Features	<ul style="list-style-type: none"> <li>• automatic emergency braking</li> <li>• blind spot warning</li> <li>• lane departure warning</li> </ul>	<ul style="list-style-type: none"> <li>• lane centering OR</li> <li>• adaptive cruise control</li> </ul>	<ul style="list-style-type: none"> <li>• lane centering AND</li> <li>• adaptive cruise control at the same time</li> </ul>	<ul style="list-style-type: none"> <li>• traffic jam chauffeur</li> </ul>	<ul style="list-style-type: none"> <li>• local driverless taxi</li> <li>• pedals/steering wheel may or may not be installed</li> </ul>	<ul style="list-style-type: none"> <li>• same as level 4, but feature can drive everywhere in all conditions</li> </ul>



# Definition of Autonomous Driving

- Classification by Technical Level



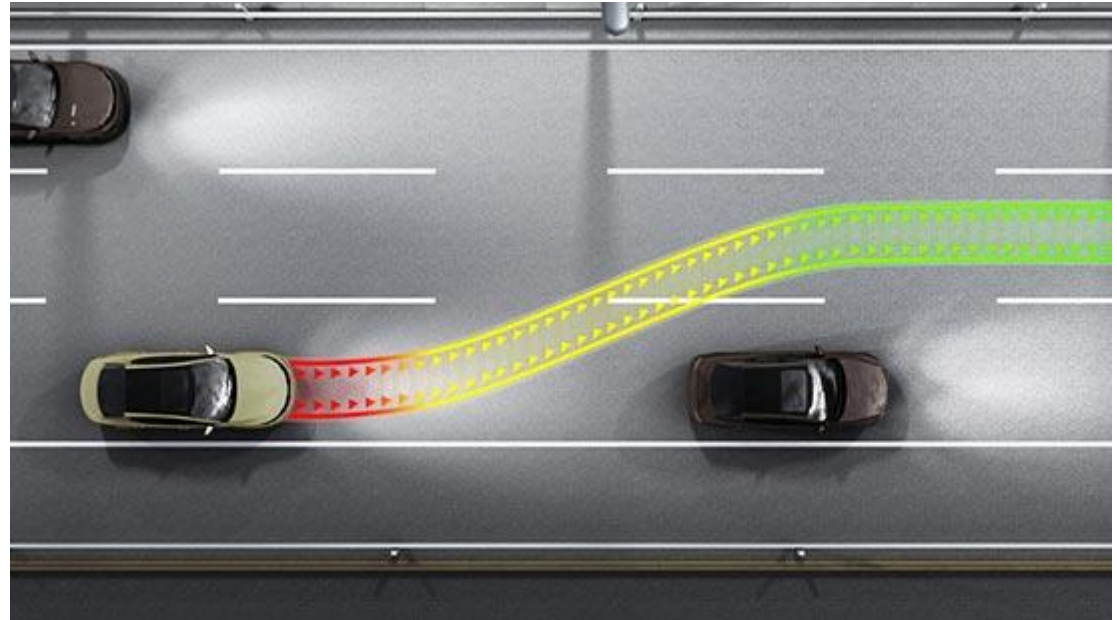
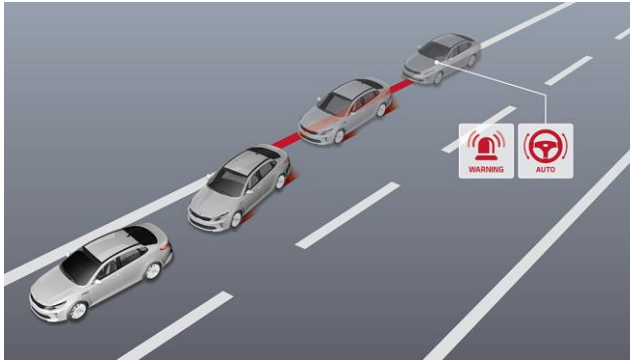


# Definition of Autonomous Driving

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## ▪ Current AD system?

- maybe...level 2...?
- ADAS (advanced driving assistance system)



# Module of AD system

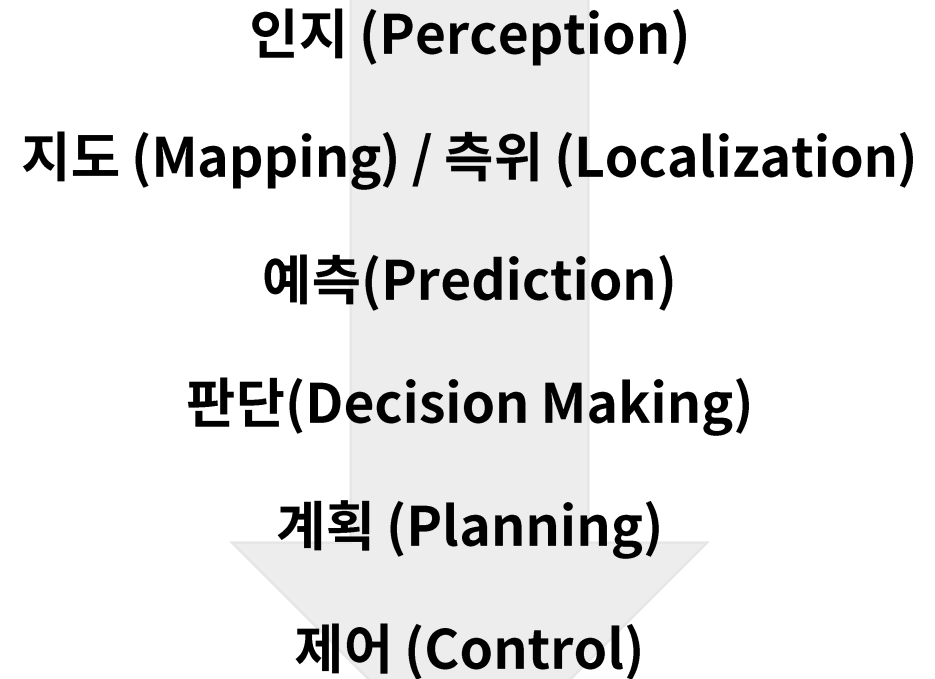
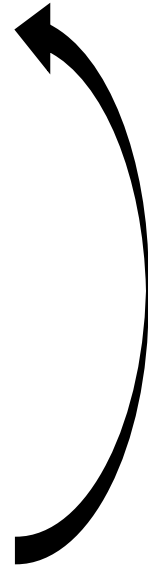
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# Module of AD system

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## ▪ What is autonomous driving?

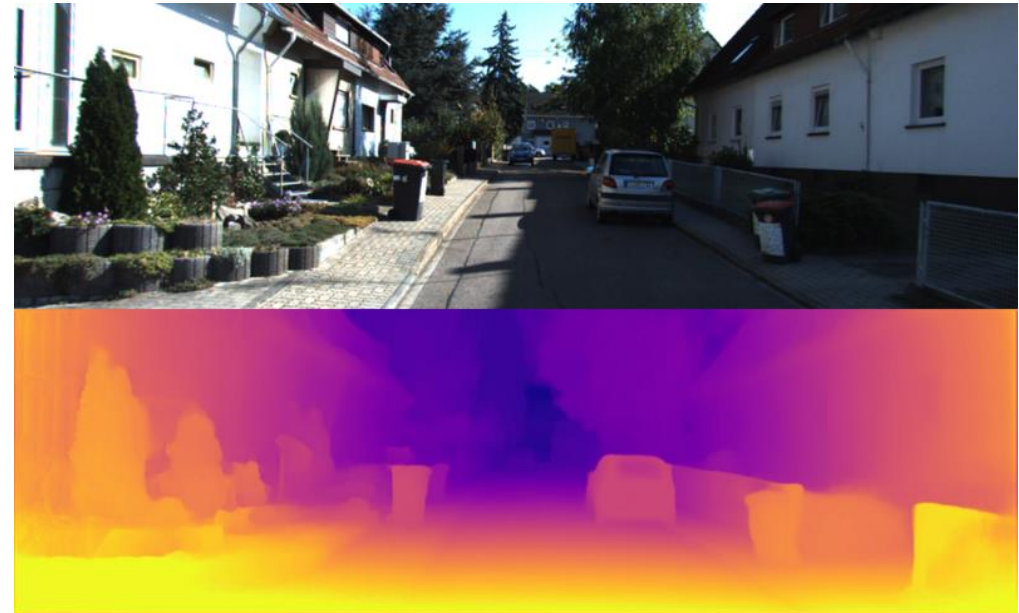
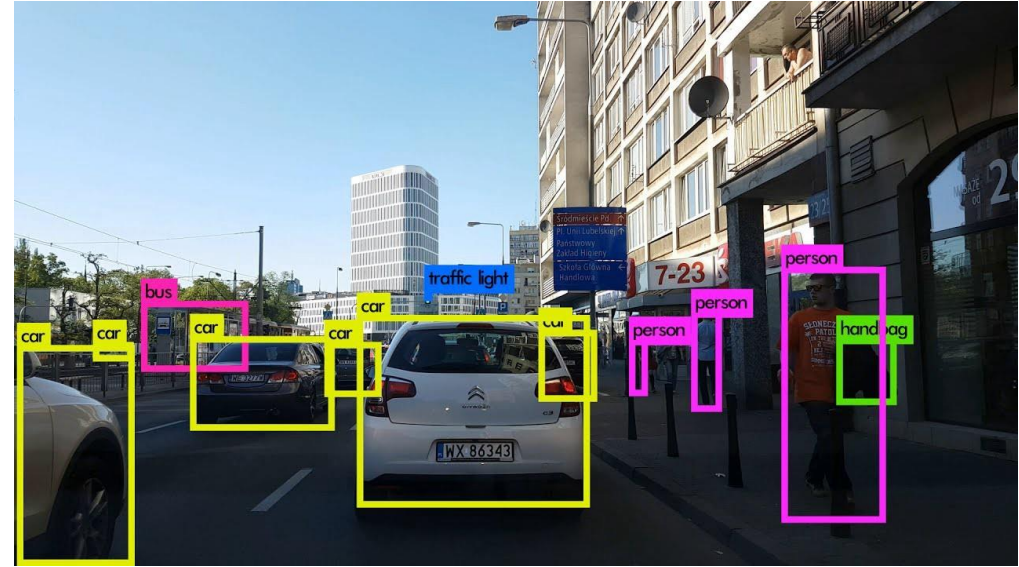
- To reach the goal
  - 주변에 무엇이 있는가
  - 여긴 어디이고
  - 나는 어디에 있는가
  - 주변상황을 예측하고 판단한 뒤
  - 목적지까지 가기 위해 계획을 세우고
  - 적절하게 움직인다
  - ...
  - 도착했나?



# Module of AD system

- Perception

- Camera
  - Computer vision





# Module of AD system

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## ▪ Perception

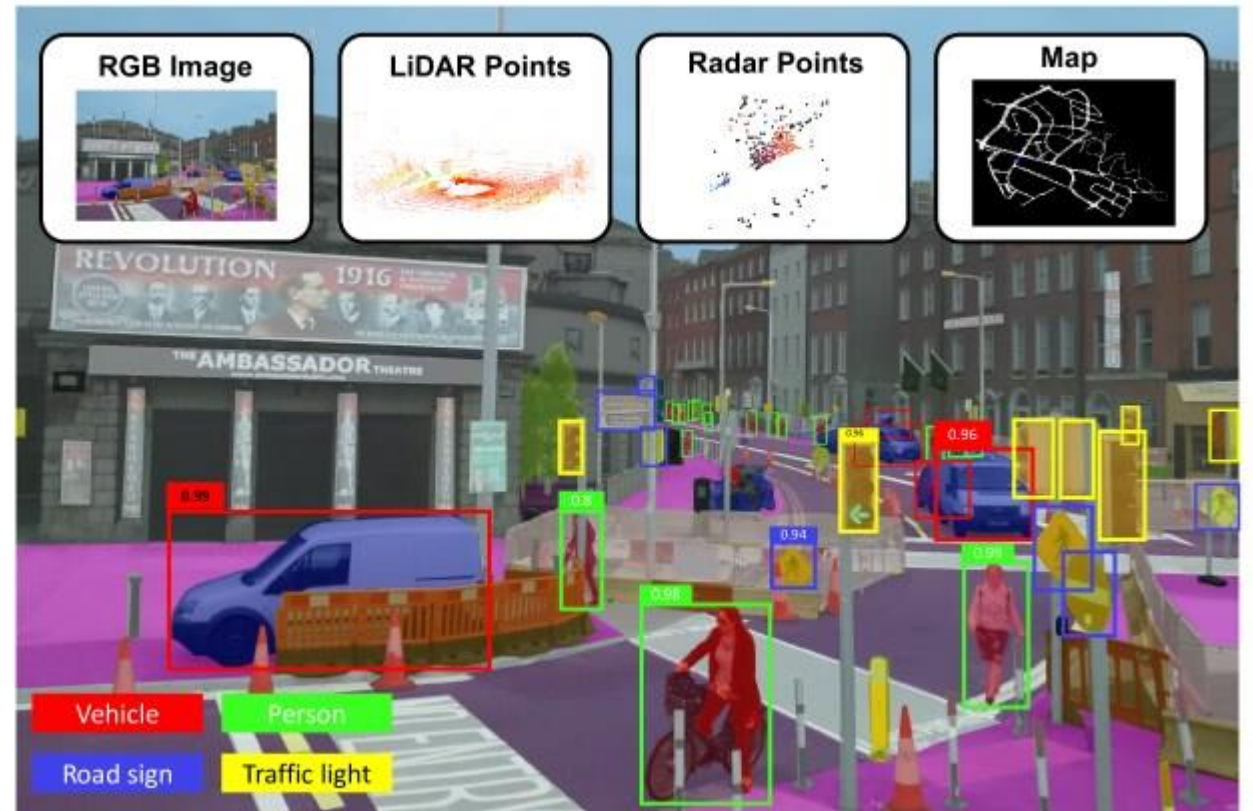
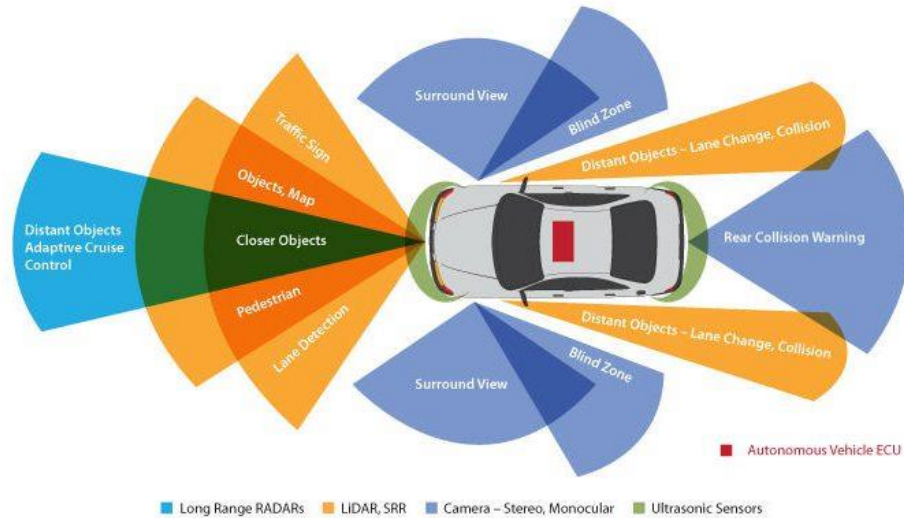
- Lidar
- Radar



# Module of AD system

## ■ Perception

- Sensor fusion
  - Pros and Cons of each sensor
- Gathering Advantages



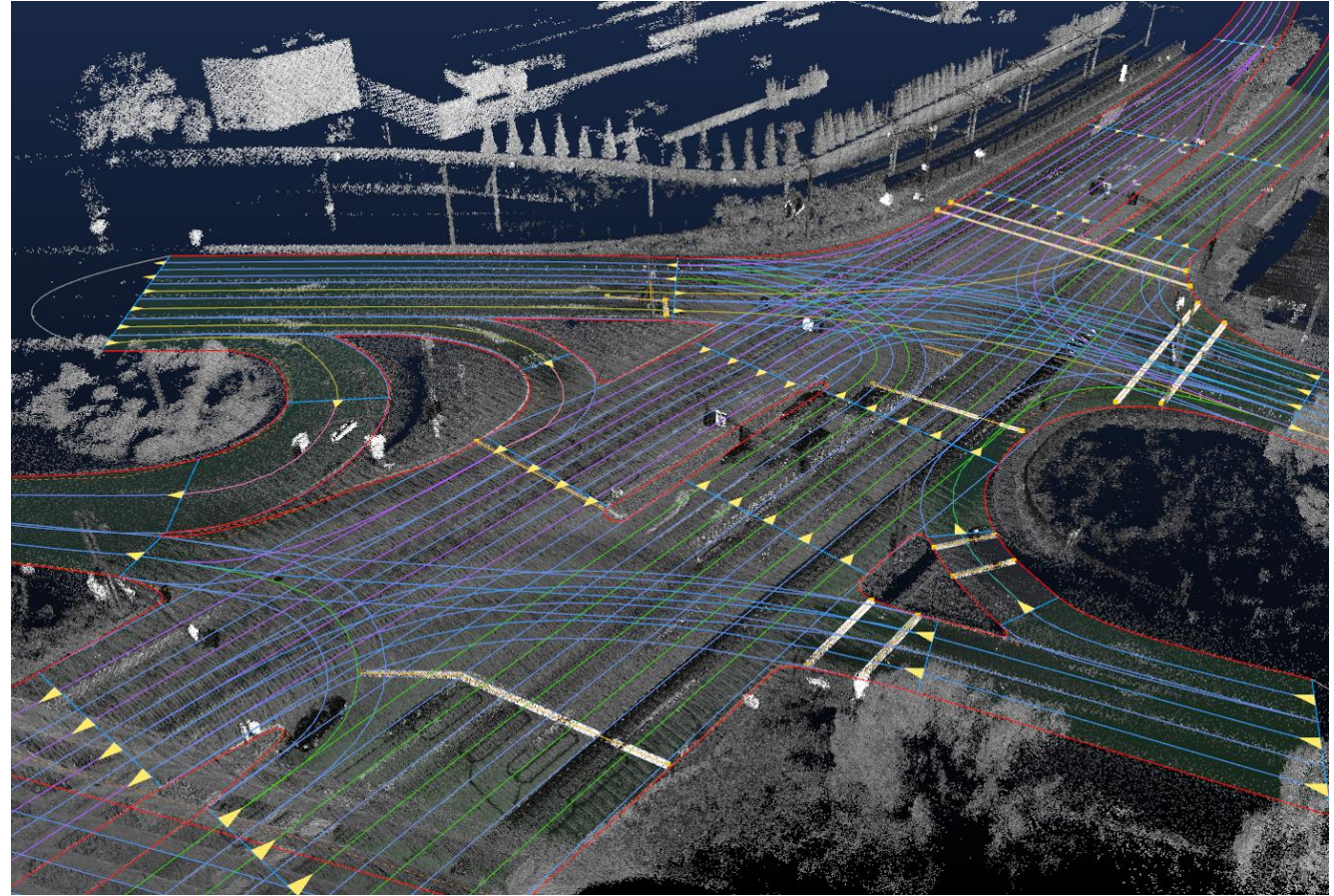
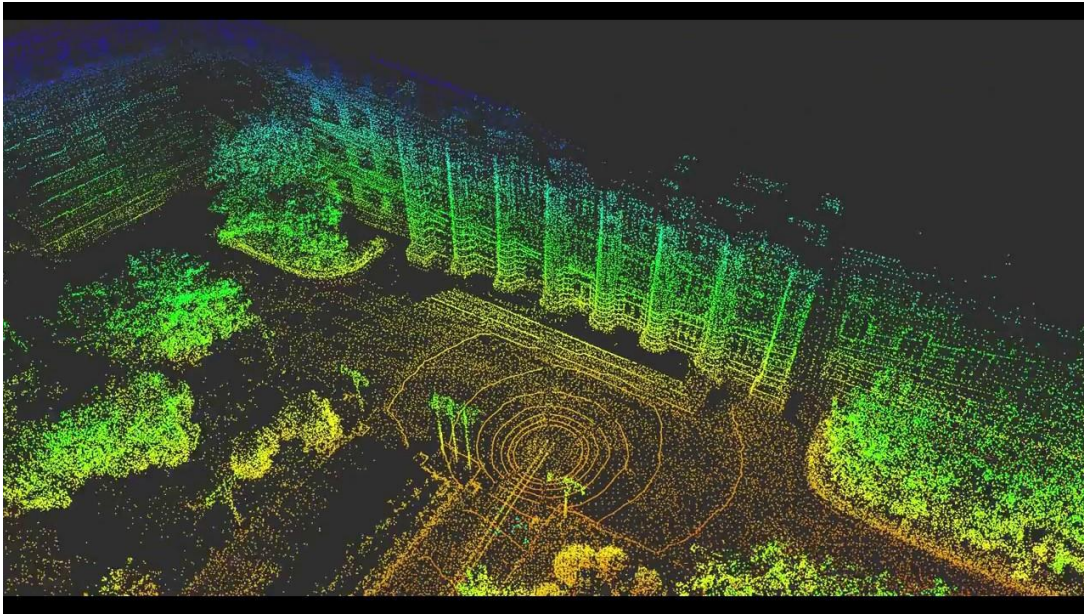


# Module of AD system

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- Mapping

- HD map



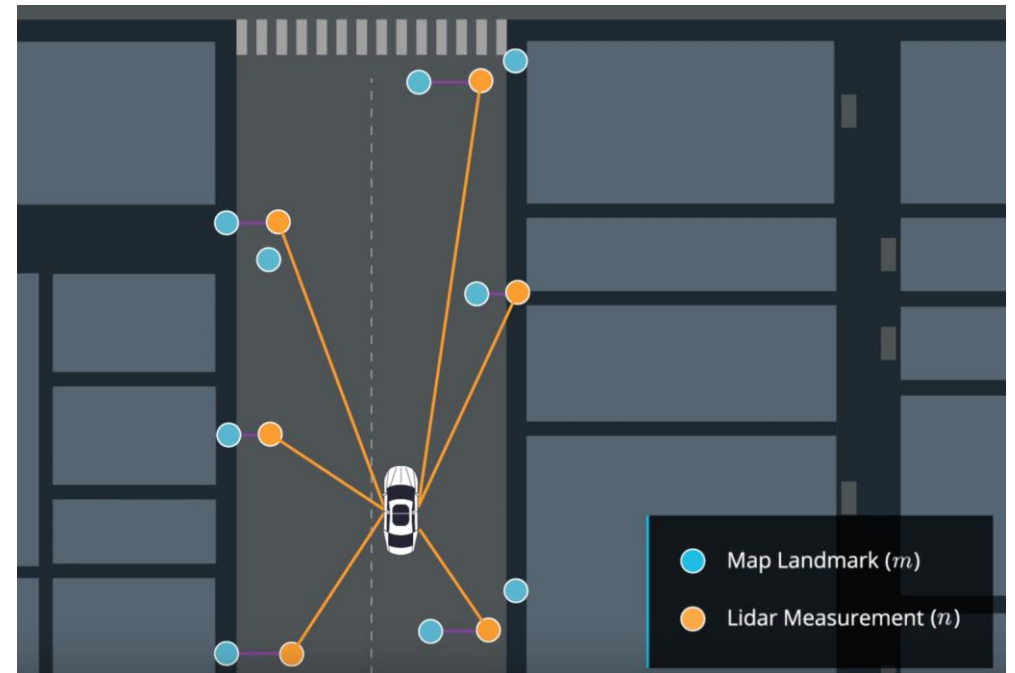
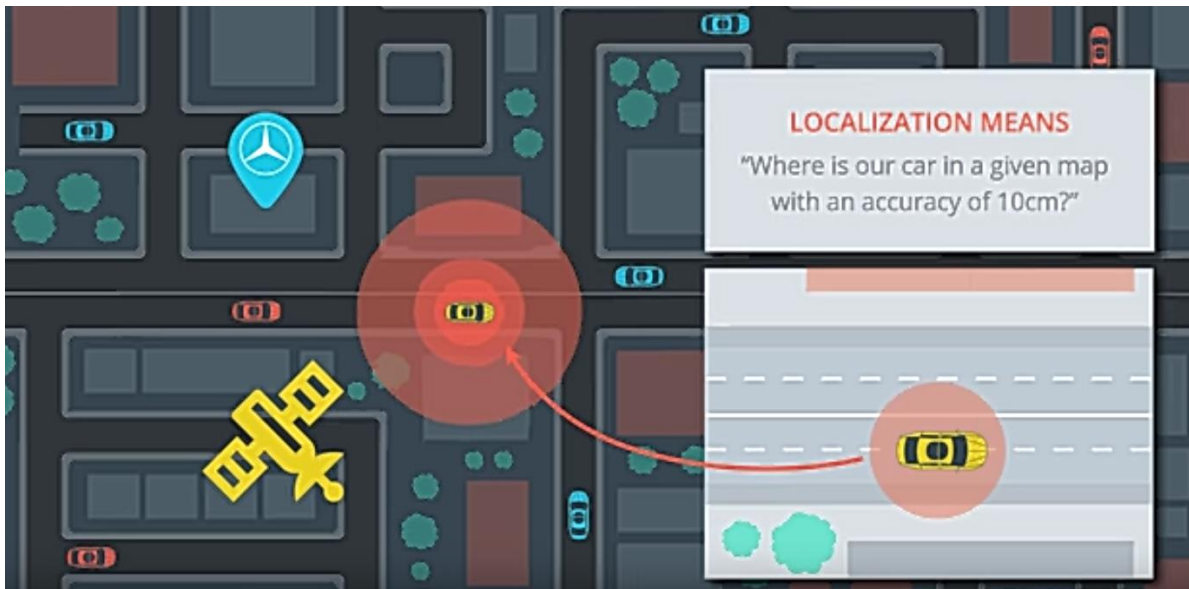


# Module of AD system

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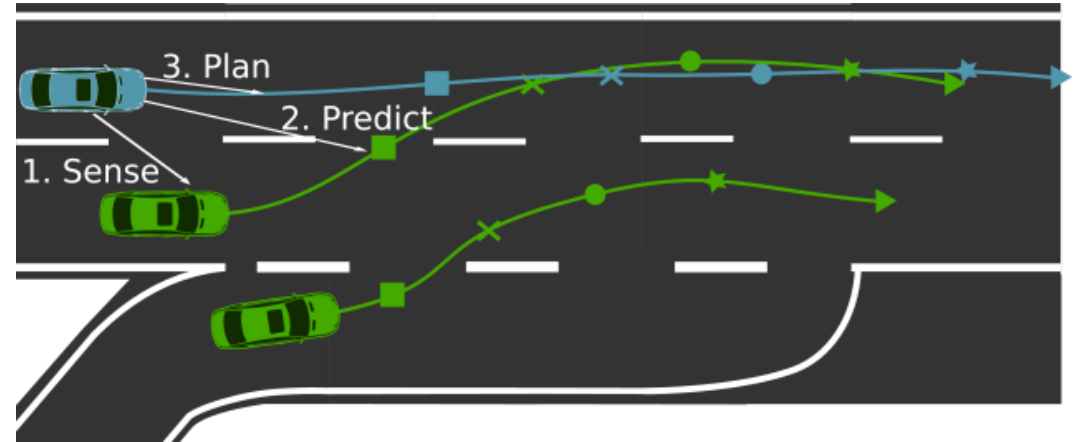
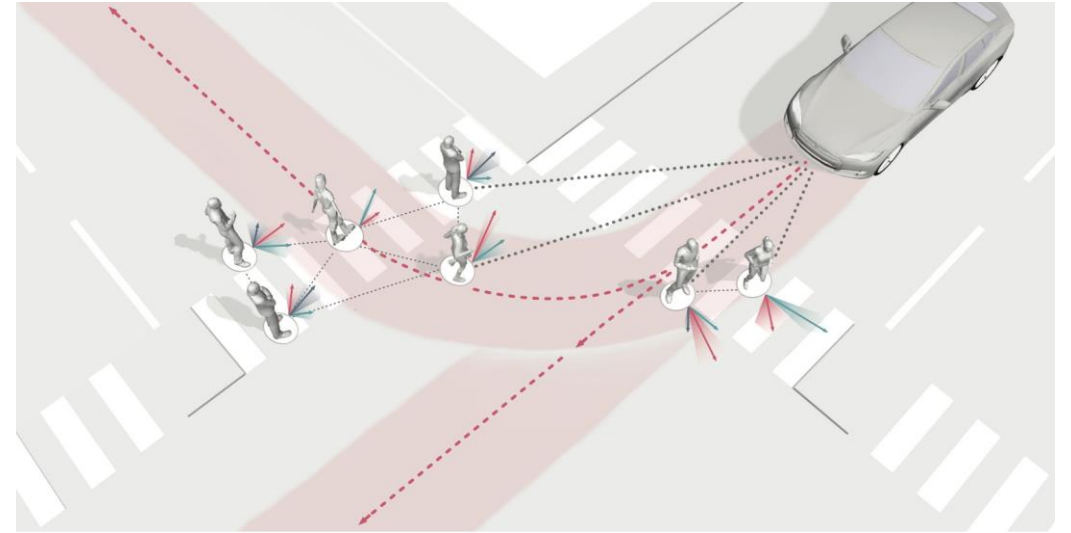
## ▪ Localization

- GPS
- Env. Sensors
- Dead reckoning



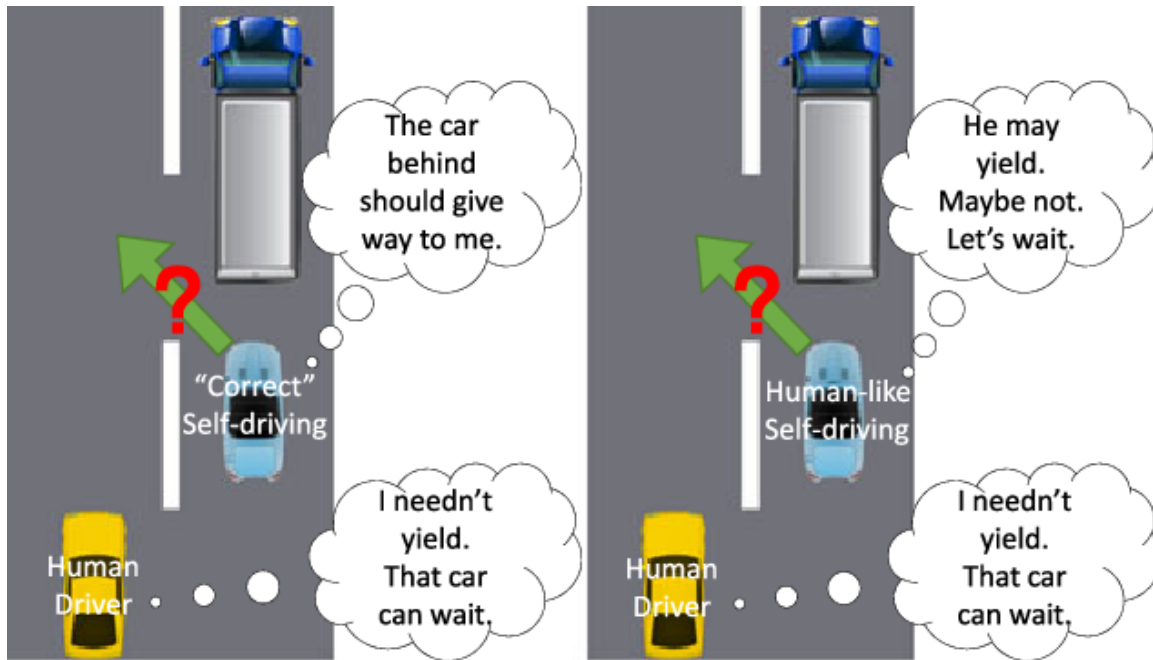
# Module of AD system

- Prediction



# Module of AD system

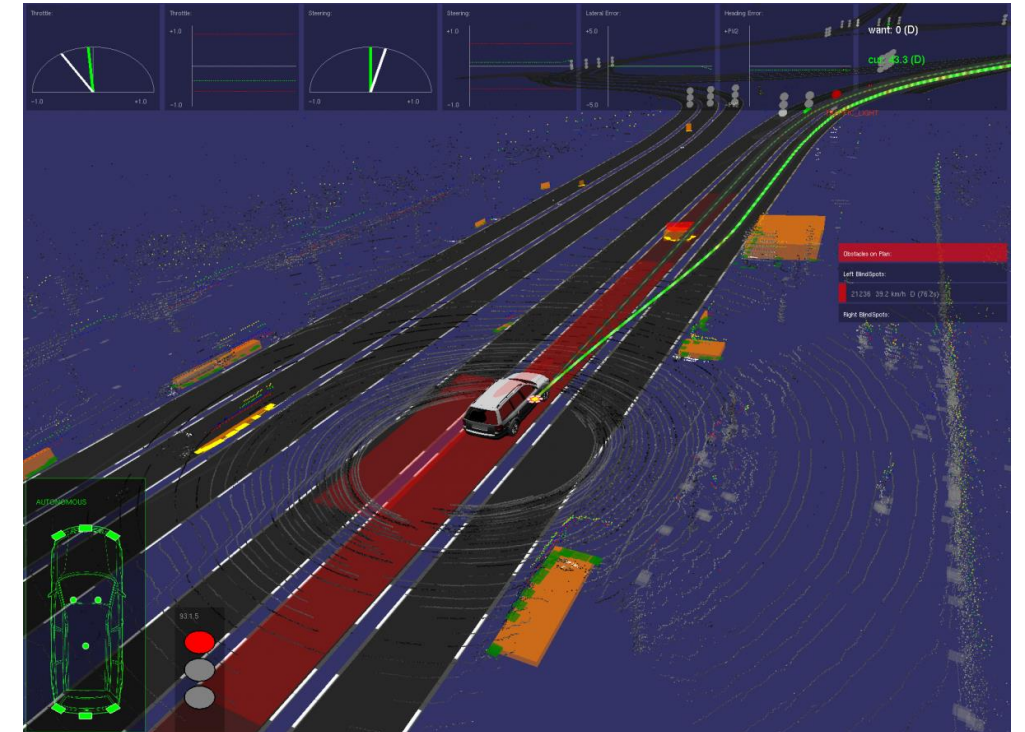
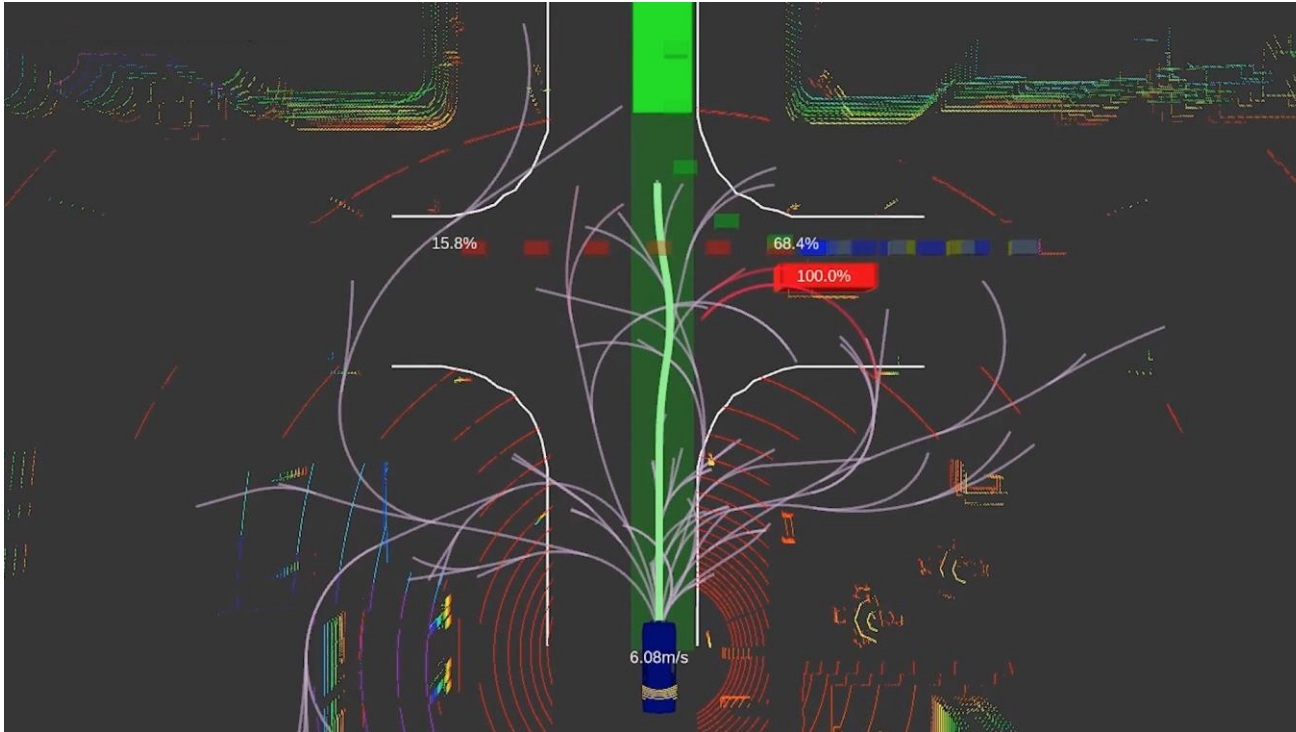
- Decision Making





# Module of AD system

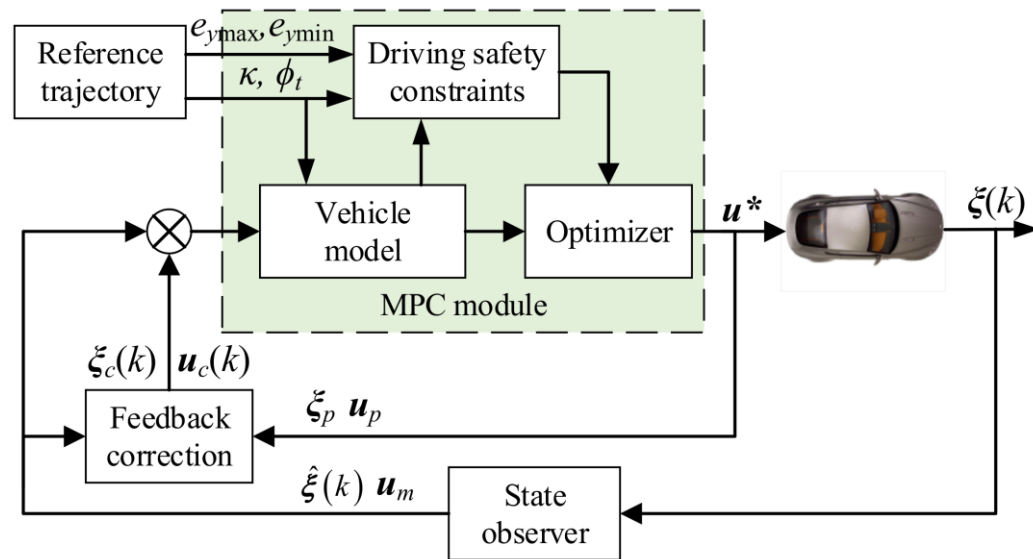
- Planning



# Module of AD system

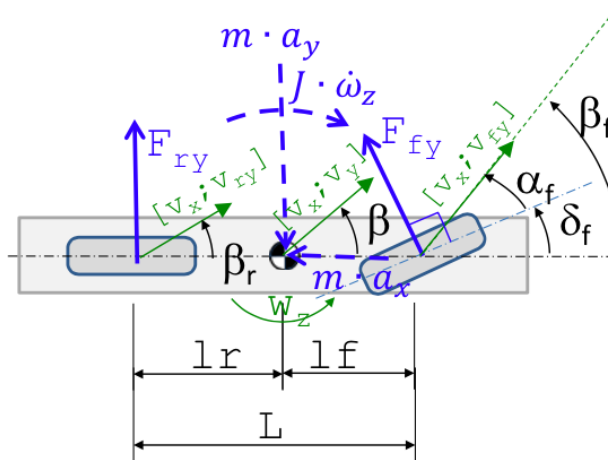
## Control

- Dynamics
- Control Theory



## Physical model:

- Path radius  $\gg$  the vehicle. Then, all forces (and centripetal acceleration) are approximately co-directed.
- Small tyre and vehicle side slip. Then,  $\text{angle} = \sin(\text{angle}) = \tan(\text{angle})$ .  
(Angles are not drawn small, which is the reason why the forces not appear co-linear in figure.)



## Mathematical model:

### Equilibrium:

$$\begin{aligned} m \cdot (\dot{v}_x - \omega_z \cdot v_y) &\approx F_{fx} + F_{rx}; \text{ where } \dot{v}_x = 0; \\ m \cdot (\dot{v}_y + \omega_z \cdot v_x) &\approx F_{fy} + F_{ry}; \\ J \cdot \dot{\omega}_z &\approx F_{fy} \cdot l_f - F_{ry} \cdot l_r; \end{aligned}$$

**Constitution:**  $F_{fy} = -C_f \cdot s_{yf}$ ;  $F_{ry} = -C_r \cdot s_{yr}$ ;

### Compatibility:

$$\left\{ \begin{aligned} \delta_f + \alpha_f &= \beta_f; \quad \beta_f \approx \frac{v_{fy}}{v_x} = \frac{v_y + l_f \cdot \omega_z}{v_x}; \\ \alpha_r &= \beta_r \approx \frac{v_{ry}}{v_x} = \frac{v_y - l_r \cdot \omega_z}{v_x}; \\ \alpha_f &\approx s_{yf}; \quad \alpha_r \approx s_{yr}; \end{aligned} \right\}$$

**Eliminate  $F_{fy}, F_{ry}, \alpha_f, \alpha_r, \beta_f, \beta_r$  yields:**

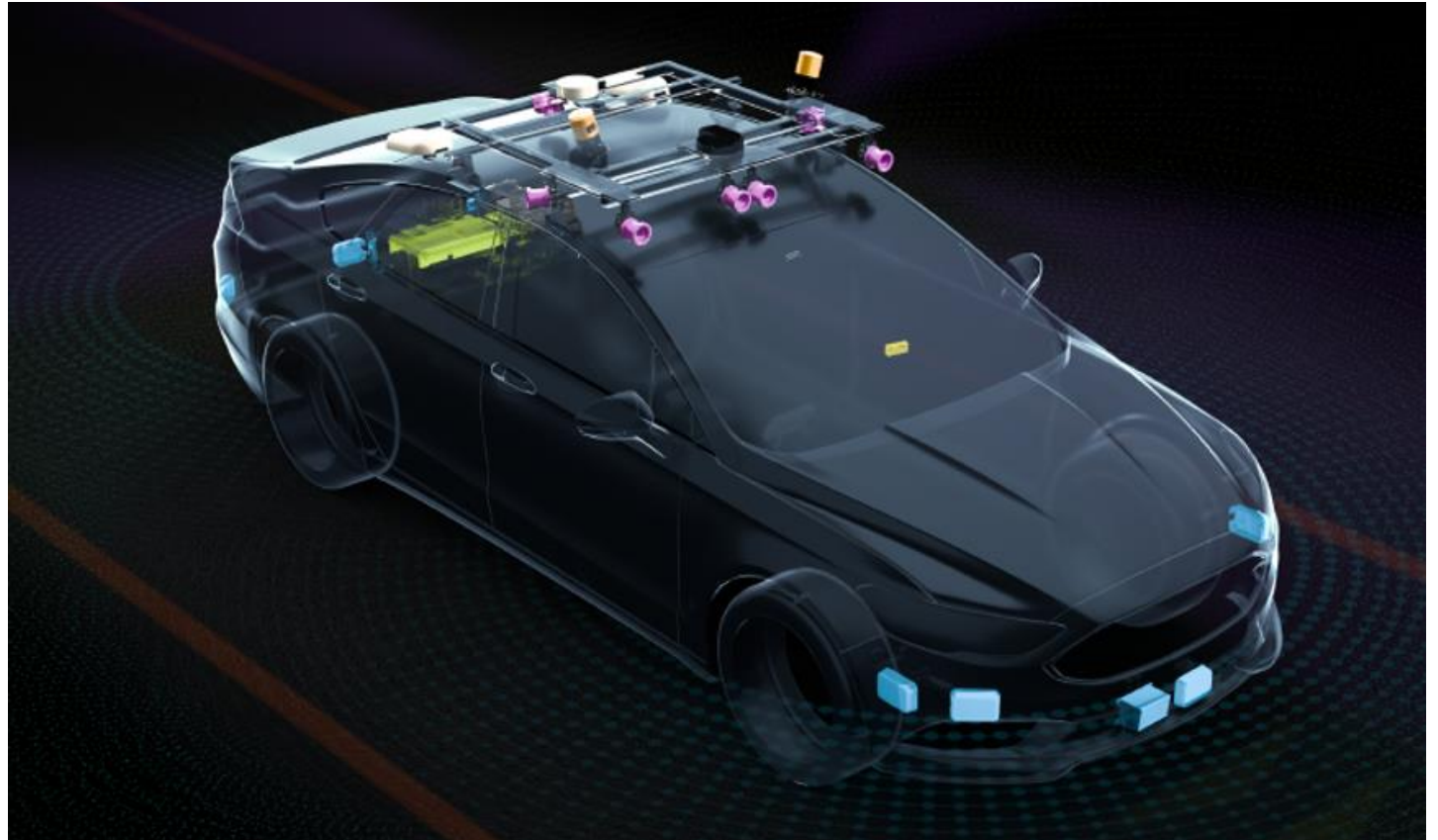
$$\begin{aligned} m \cdot \dot{v}_y + \frac{C_f + C_r}{v_x} \cdot v_y + \left( \frac{C_f \cdot l_f - C_r \cdot l_r}{v_x} + m \cdot v_x \right) \cdot \omega_z &\approx C_f \cdot \delta_f; \\ J \cdot \dot{\omega}_z + \frac{C_f \cdot l_f - C_r \cdot l_r}{v_x} \cdot v_y + \frac{C_f \cdot l_f^2 + C_r \cdot l_r^2}{v_x} \cdot \omega_z &\approx \end{aligned}$$



# Module of AD system

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- **Embedded system**
  - Low level programming
  - Optimization
- **System Arch.**



# Module of AD system

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- Validation / Test Engineer



# Module of AD system

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- What do you want?

# Required Competence

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# Required Competence

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## ▪ Collection of Technologies

- Mechanical / Electric & Electronic / Computer engineering
- Mathematics, Science, AI, Data science, Programming
- etc...

# Required Competence

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- **Understanding about Vehicle**

- Modeling/Dynamics
- Just interesting

- **Domain Knowledge**

- is still needed!!!





# Required Competence

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## ▪ SW development ability

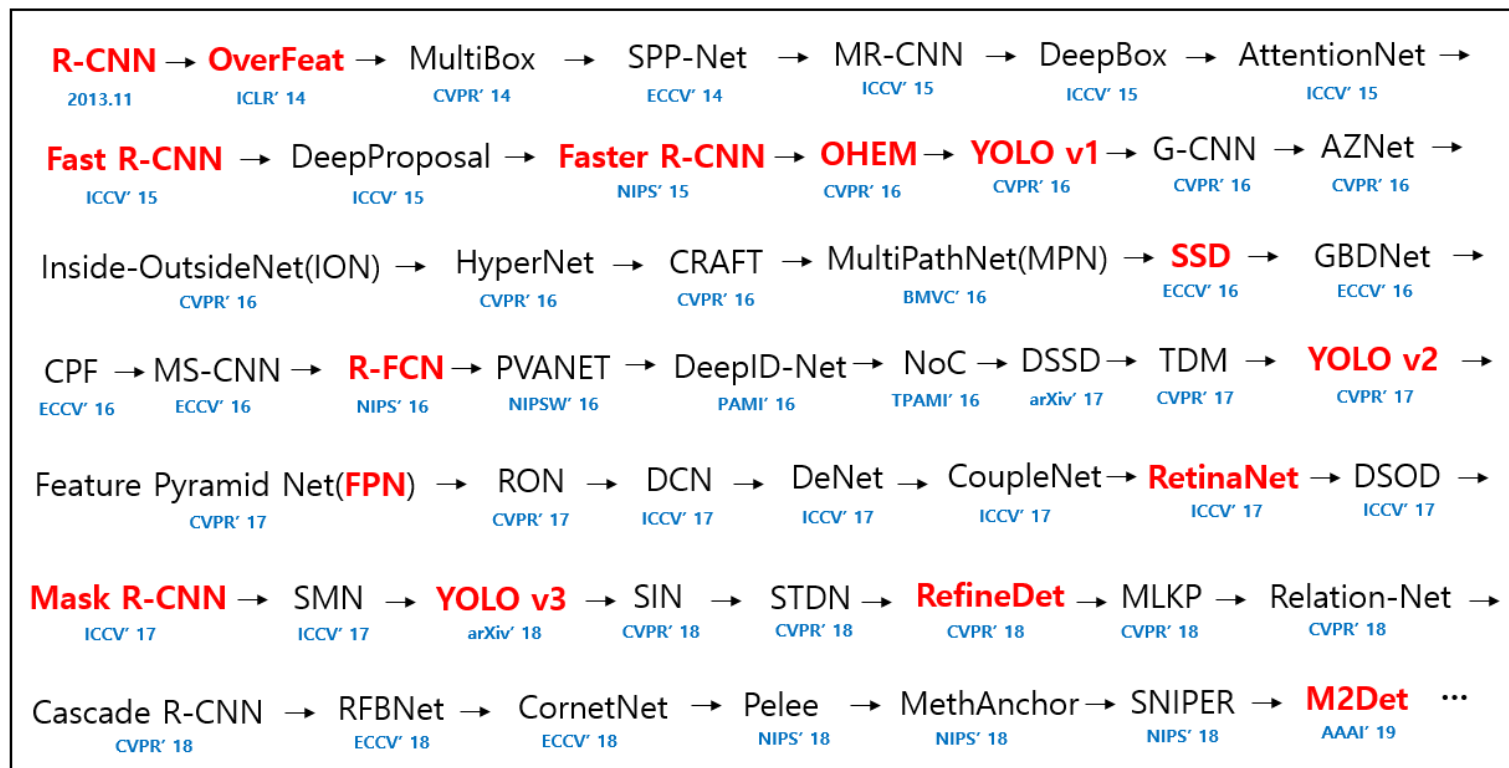
- Programming
  - You need familiar and appropriate language
  - CS knowledge - Algorithm, Data structure
- Development
  - Research alone is not enough
  - Need many many practice



# Required Competence

## ▪ Study

- Do you like study?
  - even after employment
- Enjoy new things
  - theory and some skills



# Required Competence

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- **Strong point**
  - Why should we hire you?

# Q&A

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