IDSL
Intelligent Digital Systems Design Lab.

서울과학기술대학교
SEOULTECH

AI Applications: Autonomous Driving & Physical AI & Smart Factory

Presenter **Hyun Kim** | **Associate Professor**

Affiliation Seoul National University of Science and Technology
Electrical and Information Engineering

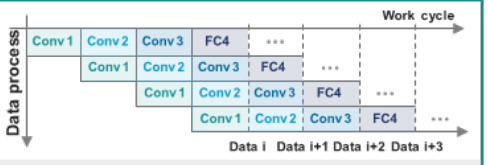
Contact hyunkim@seoultech.ac.kr / idsl.seoultech.ac.kr

Overview of On-device AI Accelerators

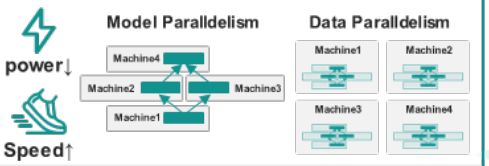
Mobile Characteristic

- Both Inference & Training
- Low-Power FPGA/ASIC for Mobile
- Low Precision: 2b/4b/8b (INT)
- Sparse network
- Application-specific accelerator design

HW-based low complexity schemes for low-power & speed-up

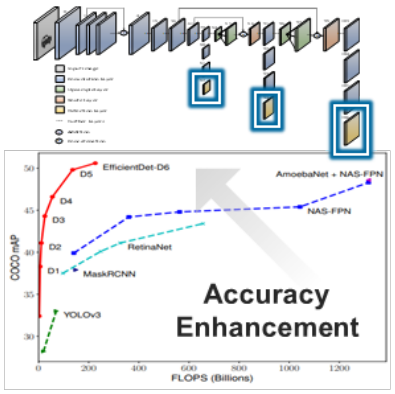


Pipelining

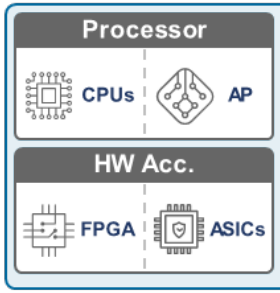


Parallelism

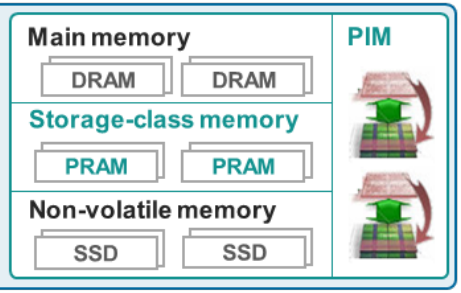
Performance enhancement schemes



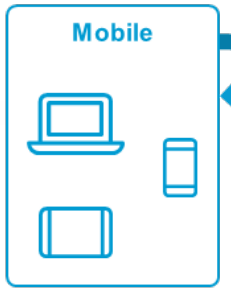
Architecture Platform



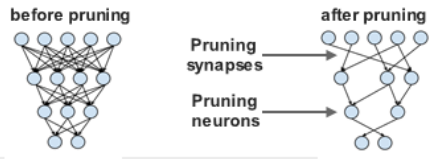
Memory System for DNNs



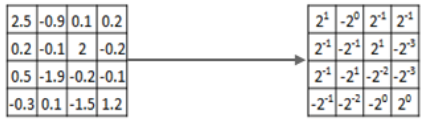
Self-Learning



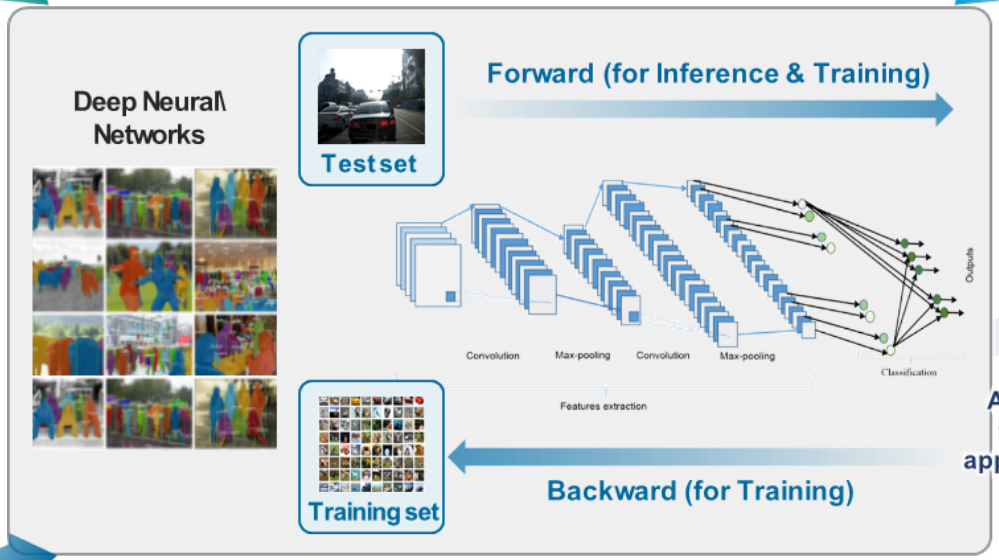
SW-based low complexity schemes for low-power & speed-up



Pruning

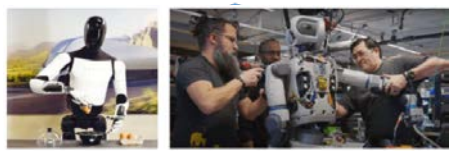


Quantization



Apply to target applications

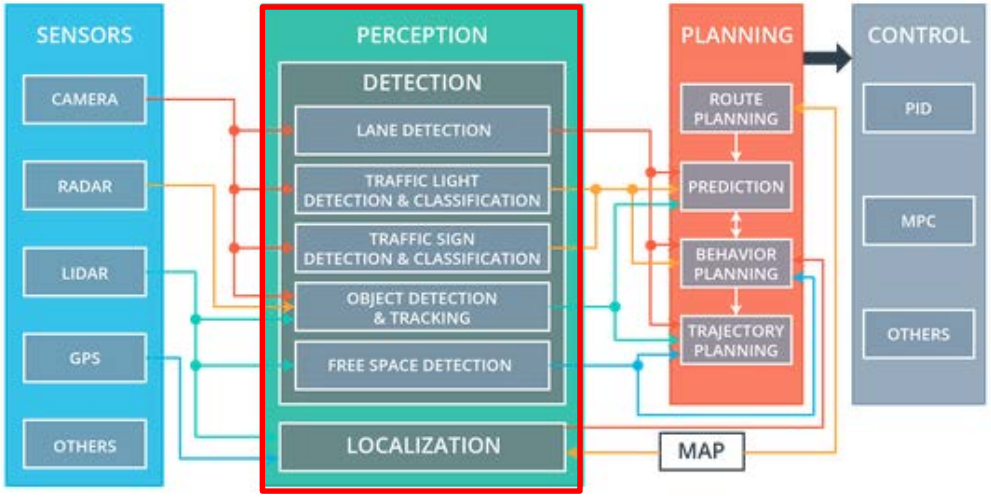
Autonomous Driving



Robot (Physical AI)

Autonomous Driving

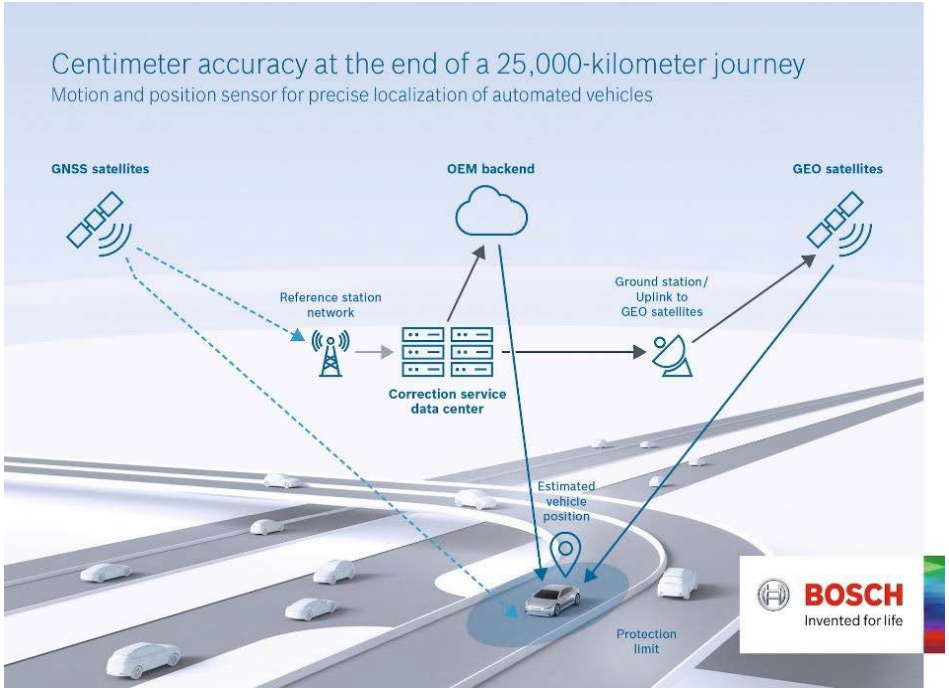
- Most representative application for mobile platform
- Operated on the limited battery



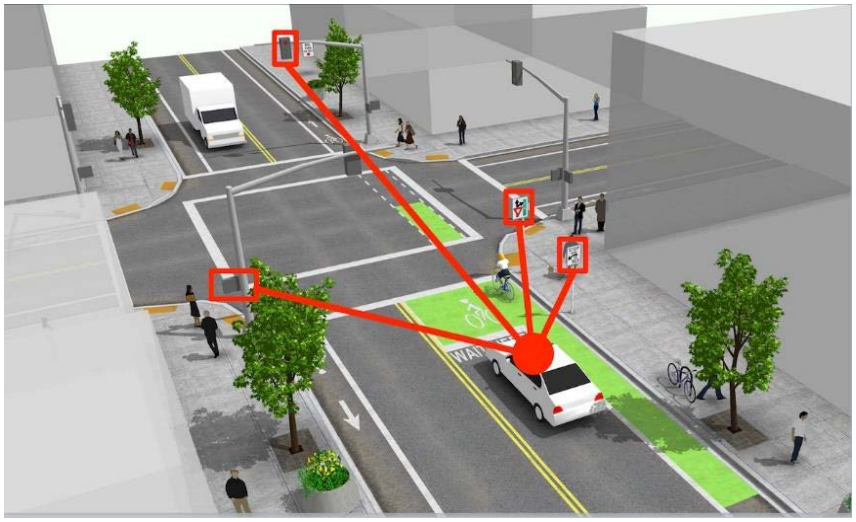
Perception (1)

LOCALIZATION

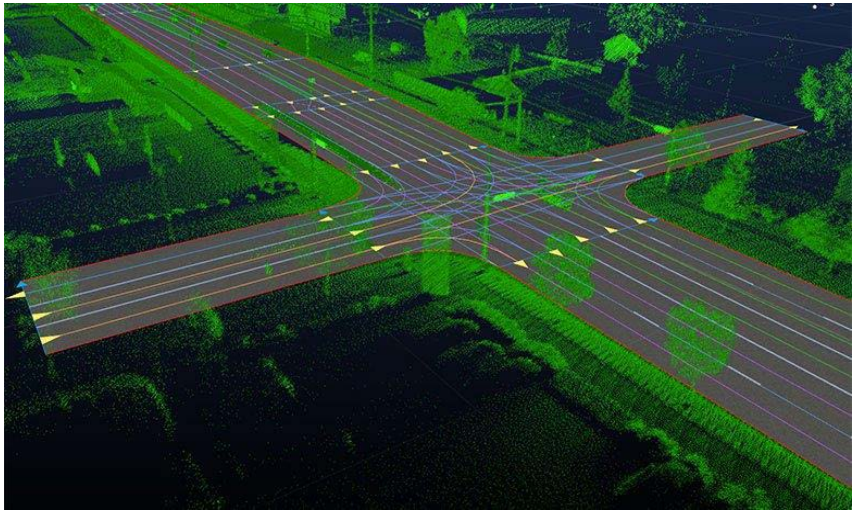
- Step implemented in the majority of robots and vehicles to locate with a really small margin of error
- Location recognition technology through precision map and GPS



GPS satellite



Road Features

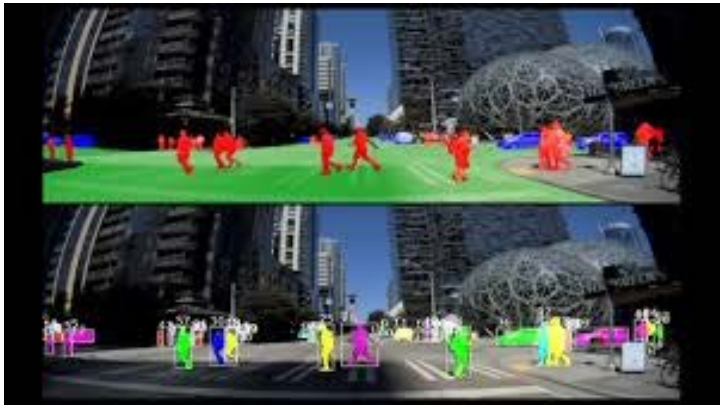


Precision Map

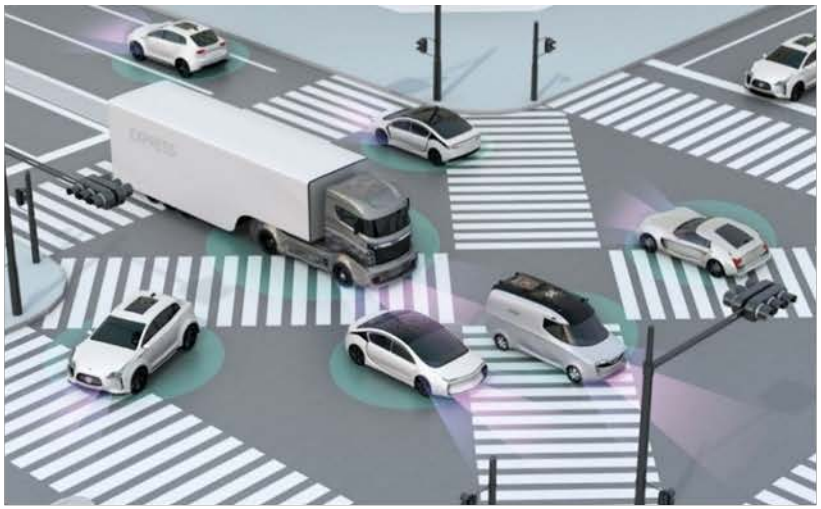
Perception (2)

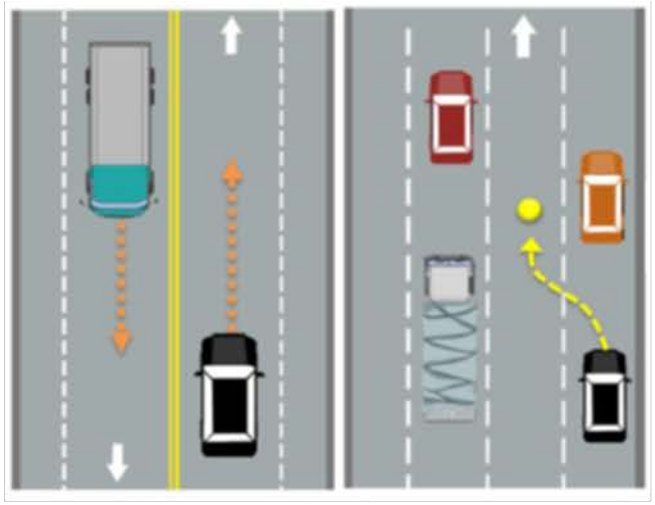
Perception of Surroundings

- Step to detect cars, pedestrians, lanes, traffic lights, traffic signs, etc. using information from various sensors
- Self-driving perception requires 100% accurate recognition of all information that a human driver perceives while driving

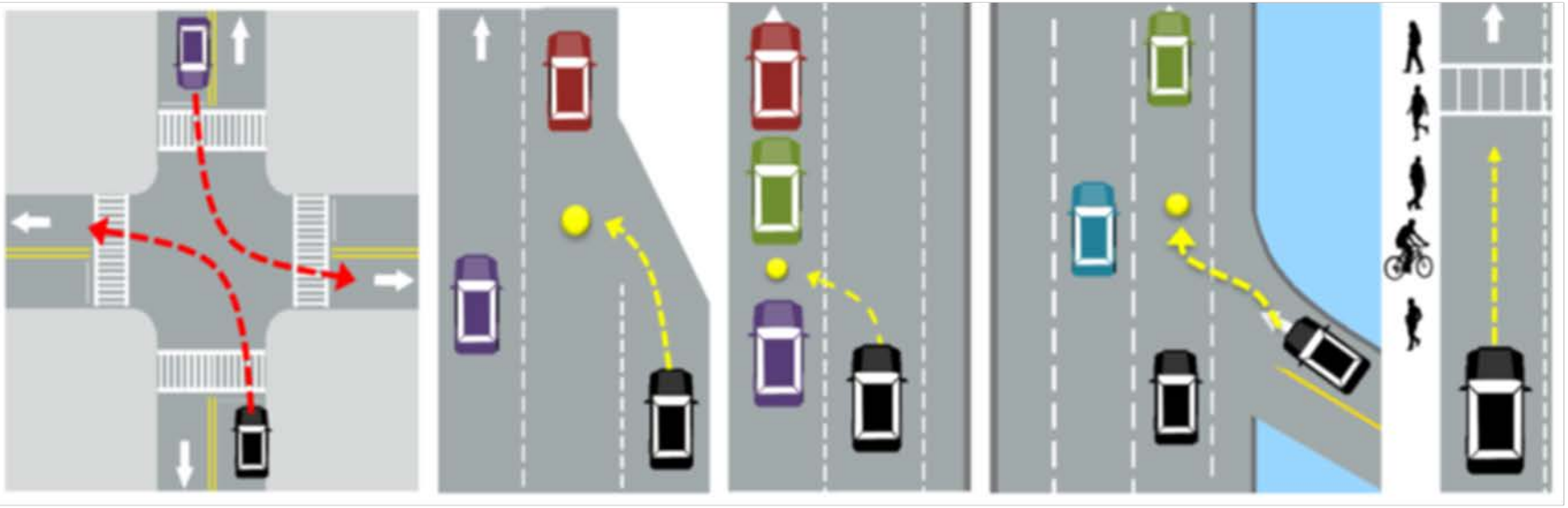


Planning



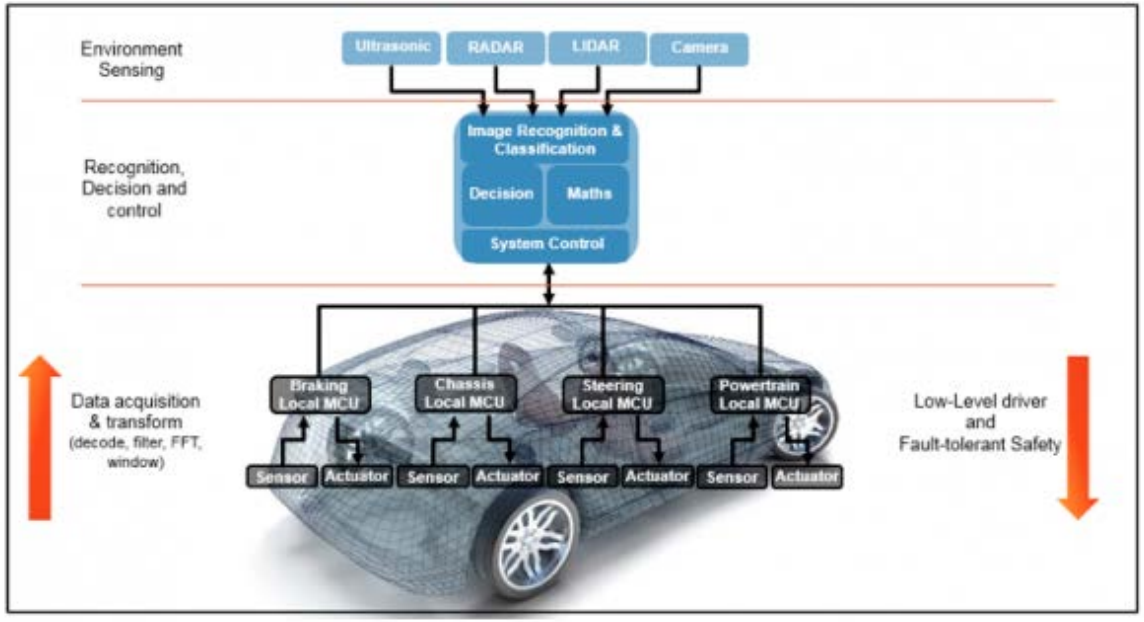


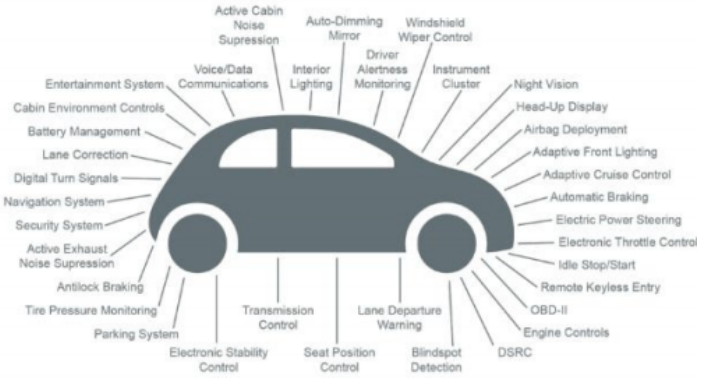
One lane driving Lane change

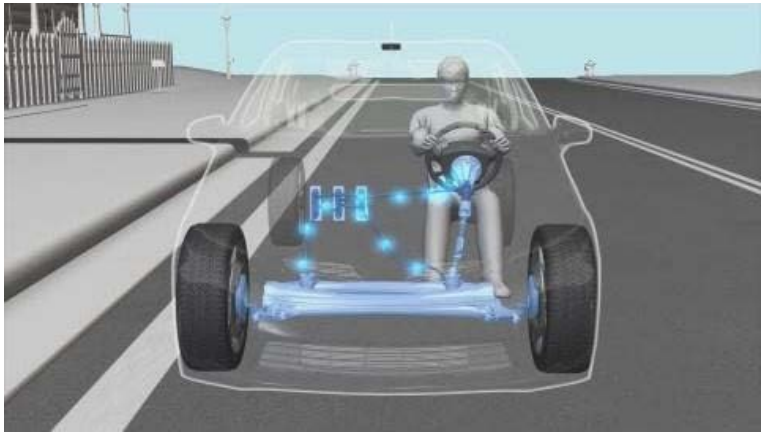


Left Turn Road confluence Cutting in line Highway access Crowded people

Control

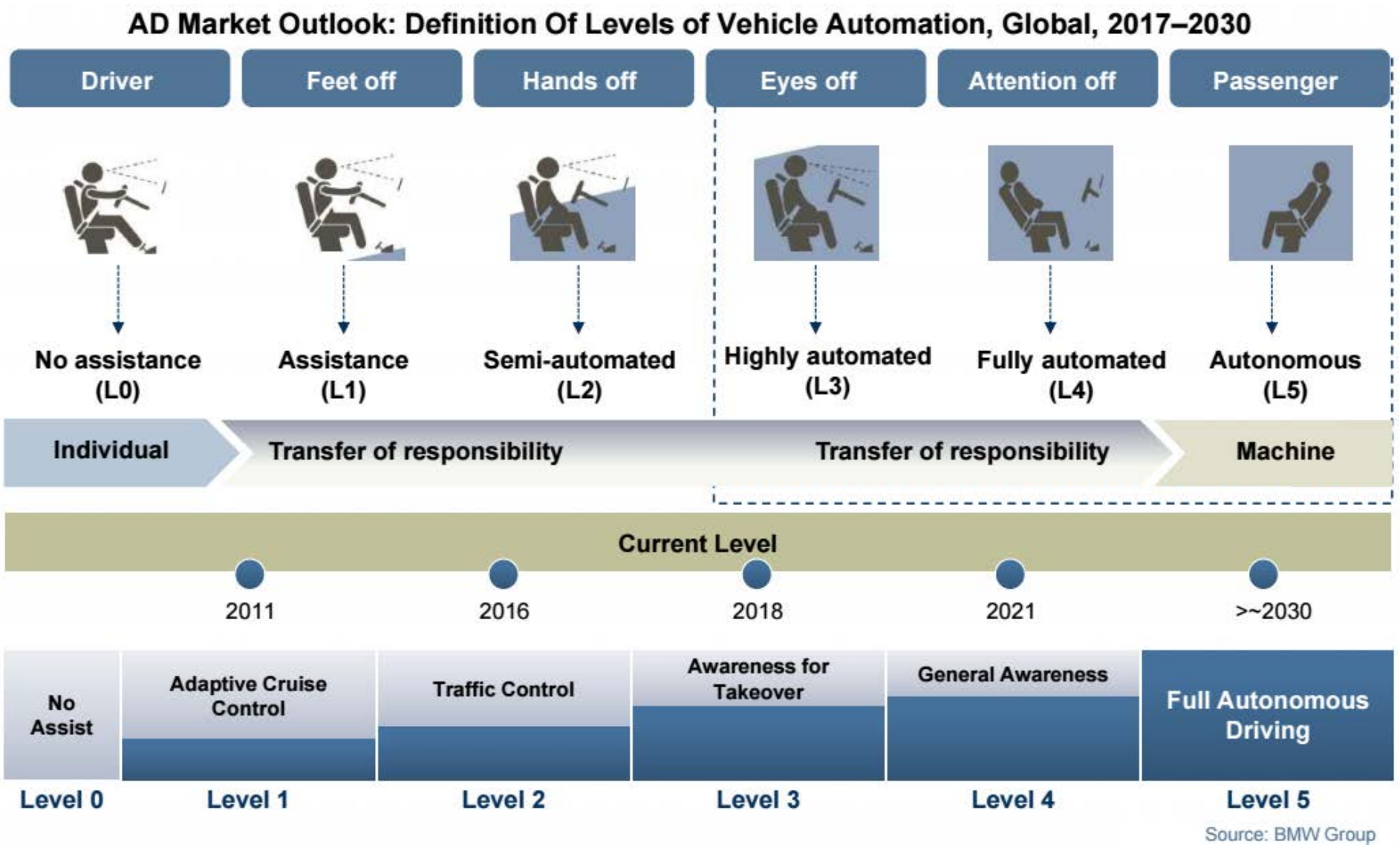

Environment Sensing
Ultrasonic
RADAR
LIDAR
Camera
Recognition, Decision and control
Image Recognition & Classification
Decision
Maths
System Control
Braking Local MCU
Chassis Local MCU
Steering Local MCU
Powertrain Local MCU
Sensor
Actuator
Data acquisition & transform
(decode, filter, FFT, window)
Low-Level driver and Fault-tolerant Safety


Active Cabin Noise Supression
Auto-Dimming Mirror
Windshield Wiper Control
Driver Alertness Monitoring
Instrument Cluster
Voice/Data Communications
Interior Lighting
Entertainment System
Cabin Environment Controls
Battery Management
Lane Correction
Digital Turn Signals
Navigation System
Security System
Active Exhaust Noise Supression
Antilock Braking
Tire Pressure Monitoring
Parking System
Night Vision
Head-Up Display
Airbag Deployment
Adaptive Front Lighting
Adaptive Cruise Control
Automatic Braking
Electric Power Steering
Electronic Throttle Control
Idle Stop/Start
Remote Keyless Entry
OBD-II
Engine Controls
DSRC
Blindspot Detection
Lane Departure Warning
Seat Position Control
Transmission Control
Electronic Stability Control



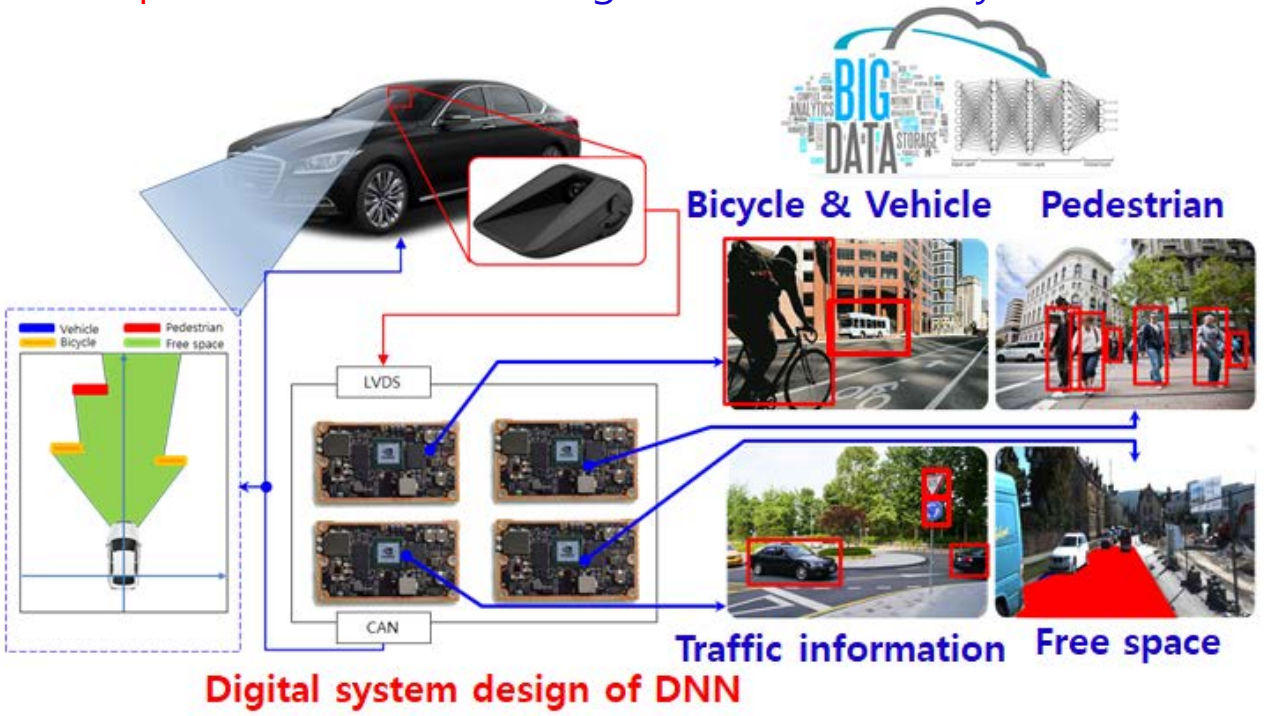

80km/h (50mph)
ESC OFF
ESC ON

Levels of Autonomous Driving



Autonomous Driving with DNN

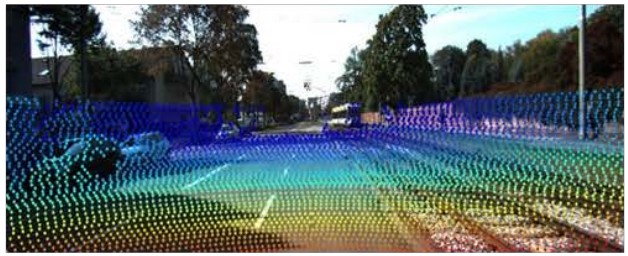
- All researchers and companies have a plan to provide level 4 autonomous driving until 2030
- Level 4 autonomous driving should detect more than 12 types of objects
- Object detection : ML-based → DNN-based for accuracy enhancement
- DNN : Too much computation due to many hidden layers → Slow speed & Significant power to be used in battery-operated auto driving ➔ Require speed-up and low-power design through **HW acceleration** & **optimization**
- Goal : Reduce the computational complexity of DNN-based algorithm to facilitate real-time operation with low-power while maintaining detection accuracy



Autonomous Driving: LiDAR

- DNN-based multi sensor fusion : RGB+LiDAR+RADAR → It requires more computation

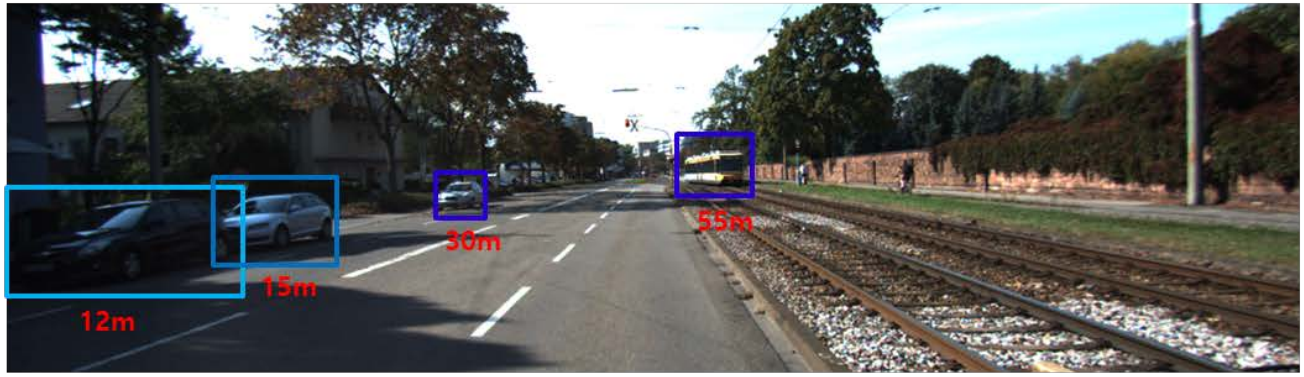
RGB camera Image



Lidar point cloud projected to 2d image

2-D Interpolation

Deep learning-based object detection using 4-channel images

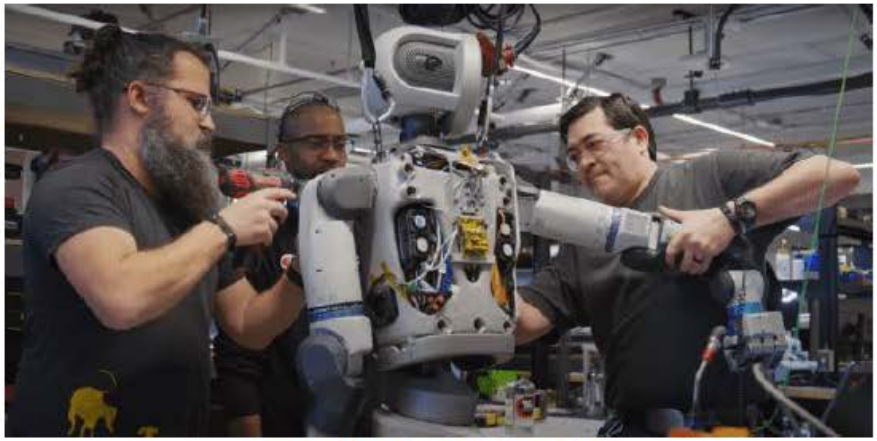


Project Leader of "Real-time mobile traffic information system based on multisensory fusion and integration"

Physical AI

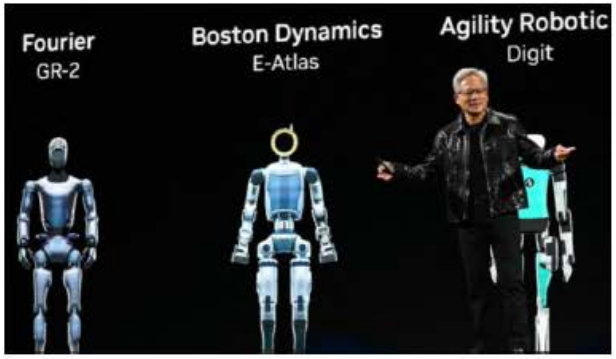
휴머노이드(humanoid) 로봇과 피지컬 AI(Physical AI) 기술의 부상

올해 테슬라 공장에 투입 예정인
휴머노이드 '옵티머스'



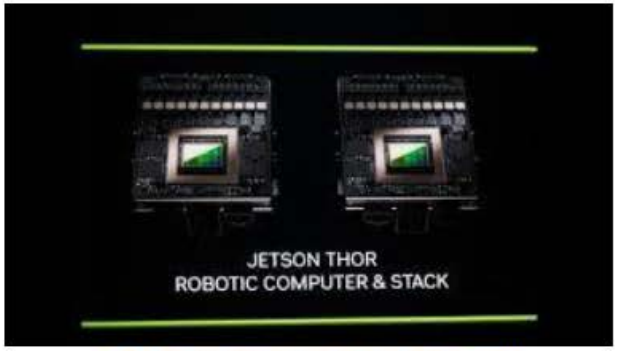
올해 현대차 공장에 투입될
보스톤 다이나믹스 휴머노이드 '아틀라스'

피규어 휴머노이드 '피규어01'



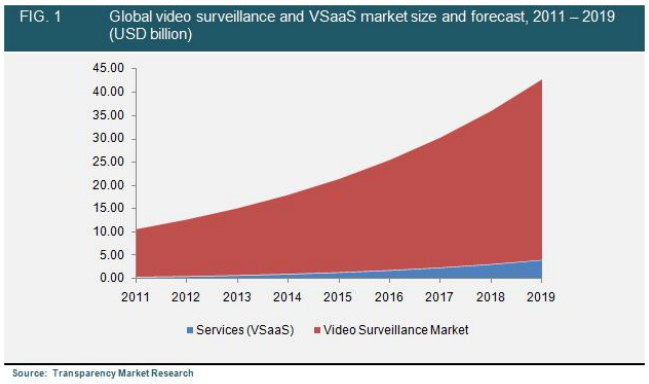
엔비디아 젠슨 황의 CES2025 기조연설

엔비디아의 피지컬AI를 위한
학습 및 시뮬레이션 플랫폼 '옴니버스



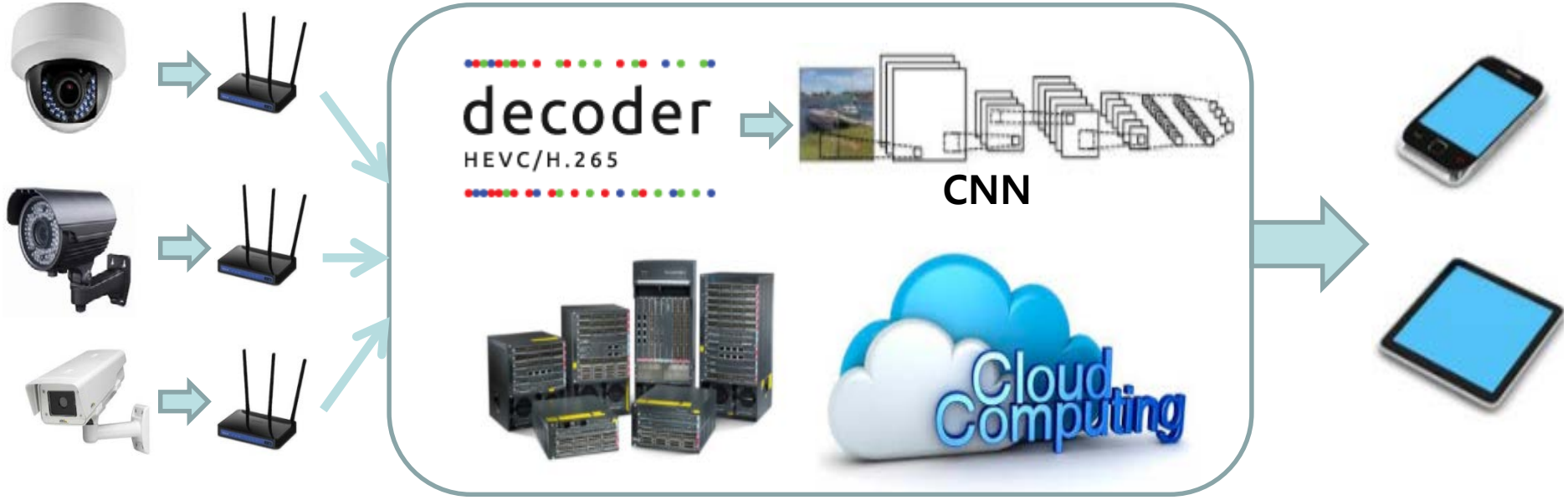
올해 출시 예정인 휴머노이드 타겟
엔비디아 'Jetson Thor'

Conventional Video Surveillance as a Service (VSaaS)

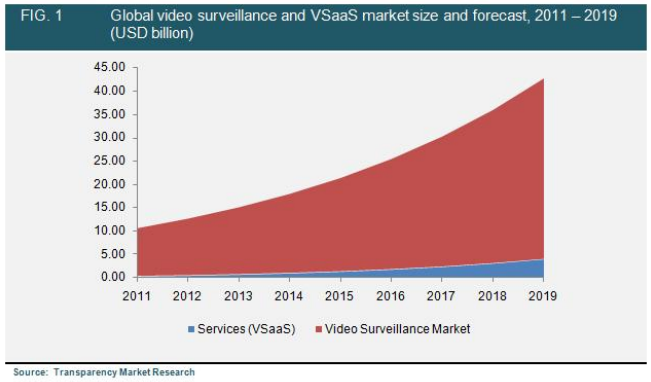


- DNN for Video Surveillance as a Service
- Application: Factory automation/Security/Smart silver care
- Advantage: Low cost, Maintenance, Scalability, Security, reusability of previous cameras
- Disadvantage: High complexity in a cloud system

Increase of VSaaS



Future VSaaS



Increase of VSaaS

- DNN for Video Surveillance as a Service
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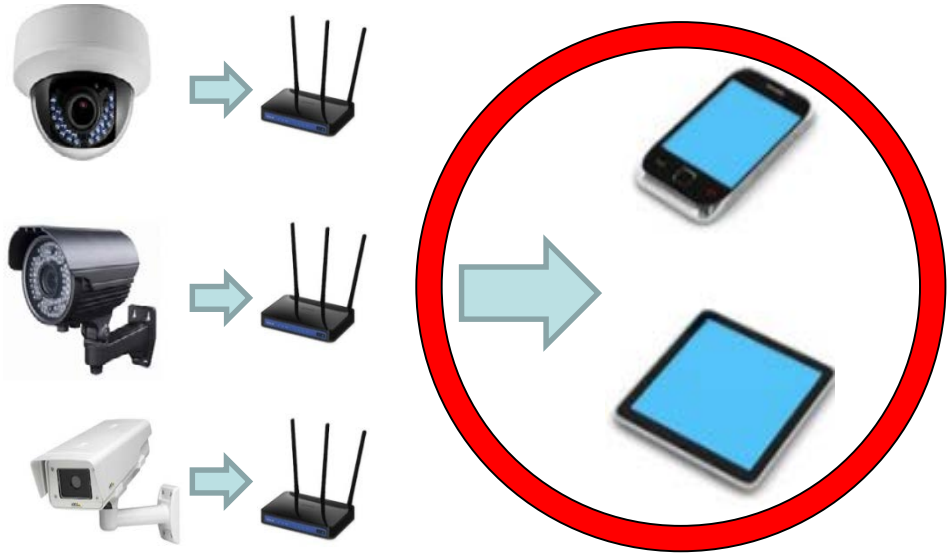
Deep learning at here!!

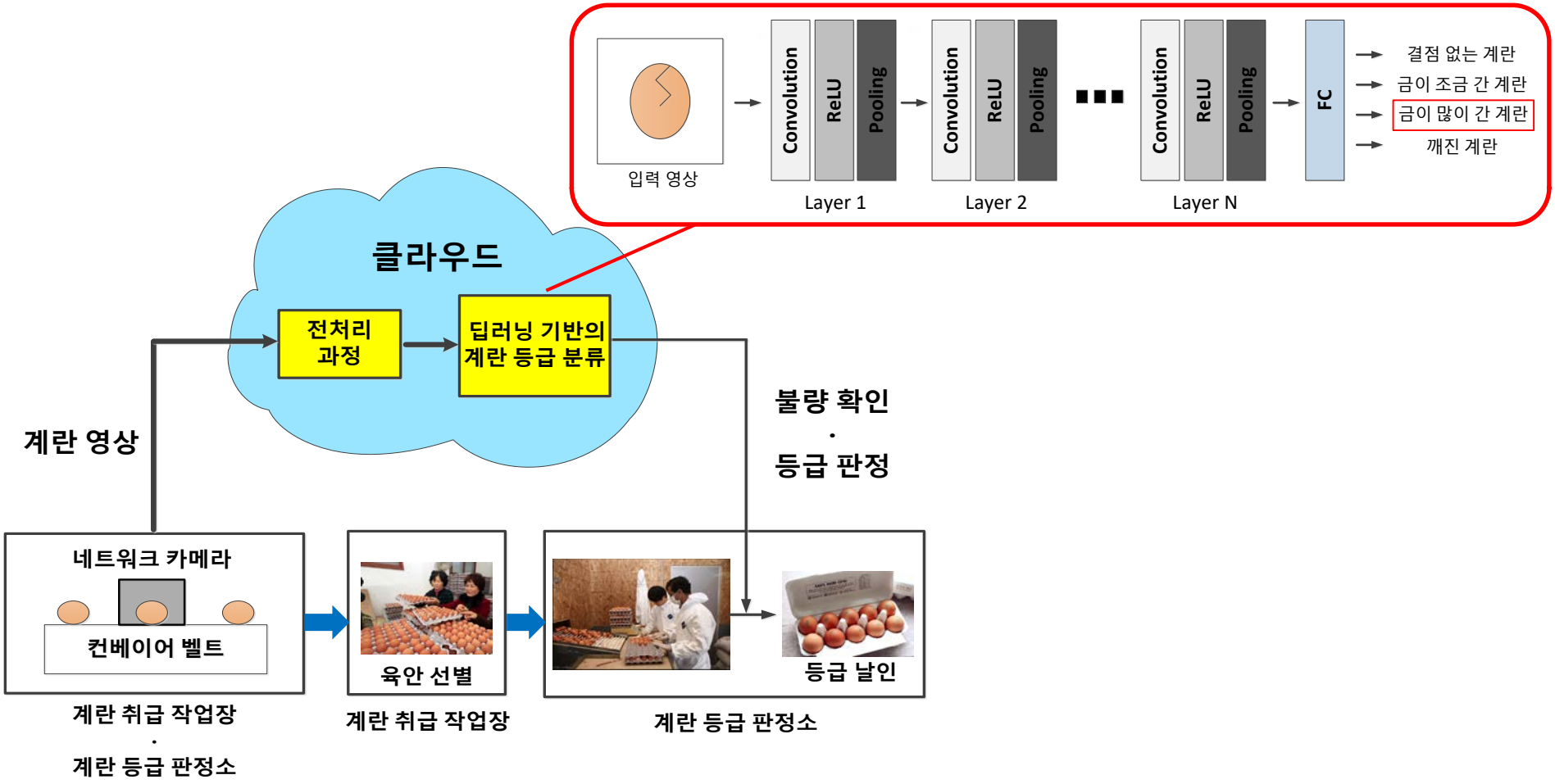


Edge Computing!!

- **Learning / Inference are performed in the mobile device → Low-power issue!!**

Application : Smart Factory

◈ Goal : Automation of many tasks that people have done in existing factories (agricultural products / semiconductors, etc)



Application : Silver Care

- Goal : Ensuring the safety of the elderly living alone through fall detection / gesture recognition based on DNN