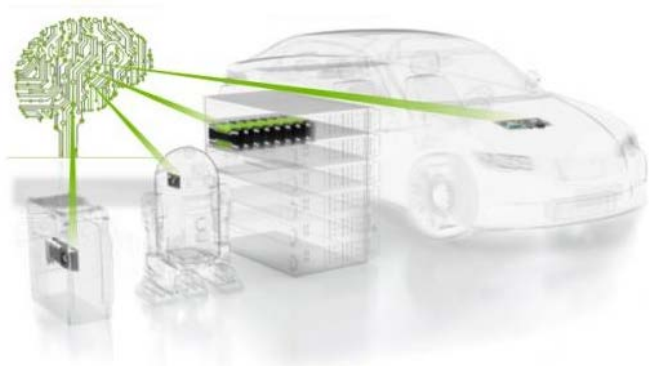
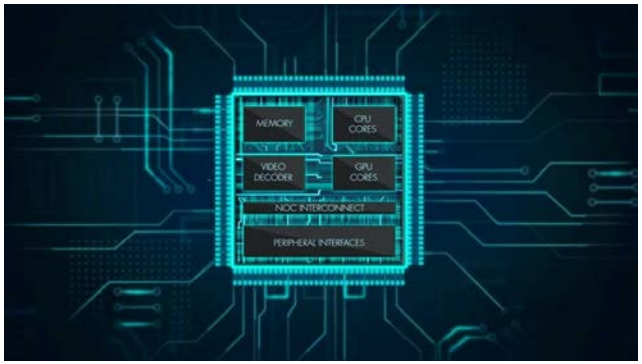


AI Applications: Autonomous Driving & Video Surveillance as a Service



Author : **Hyun Kim**

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Position : Assistant Professor

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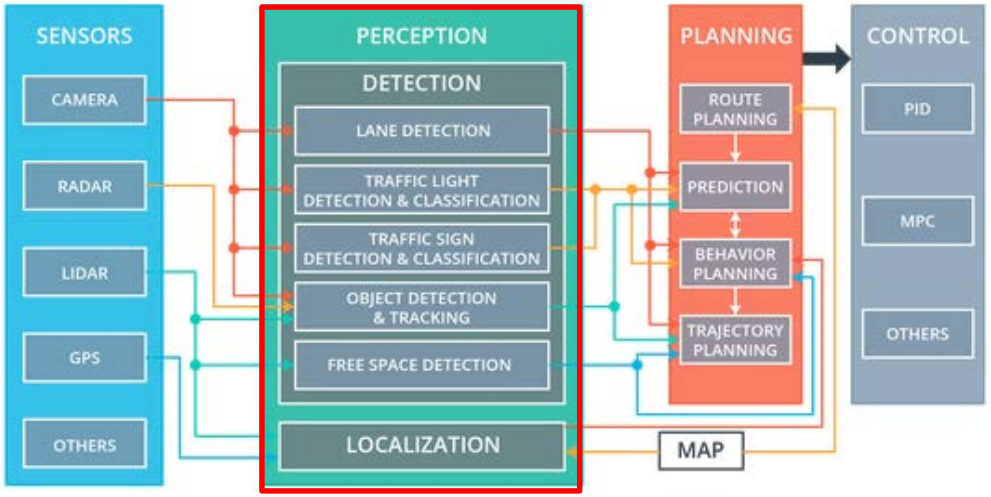
idsl.seoultech.ac.kr

Autonomous Driving

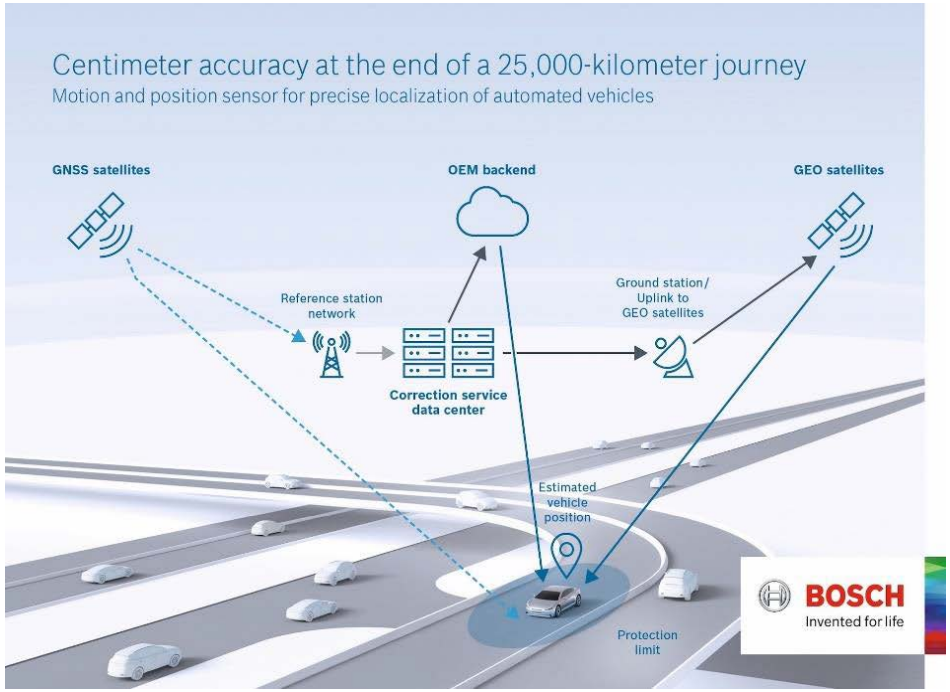
- Most representative application for mobile platform
- Operated on the limited battery



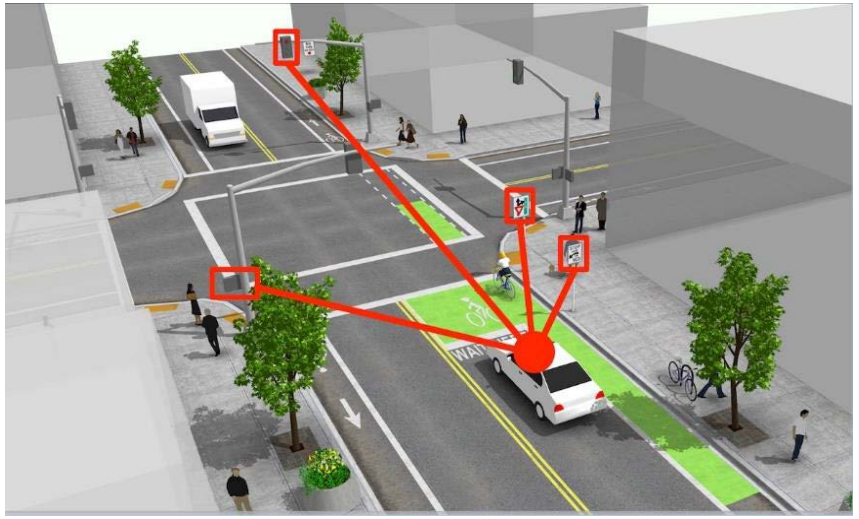
Perception (1)

LOCALIZATION

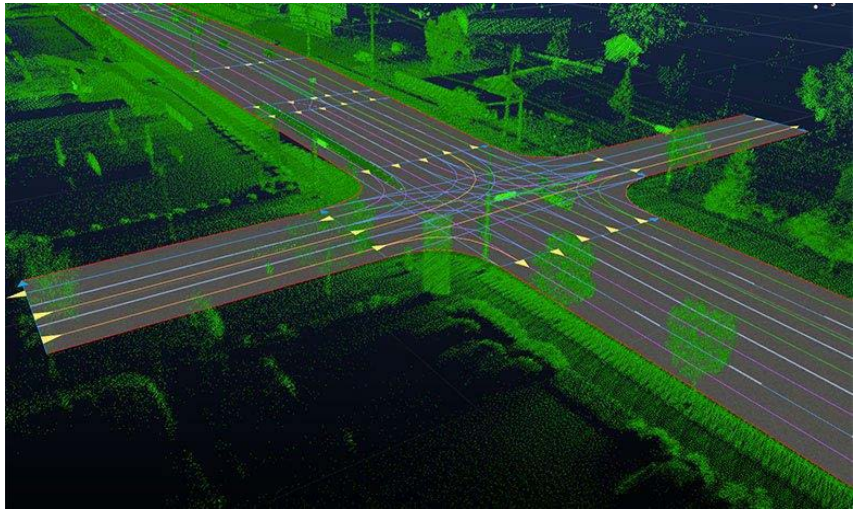
- Step implemented in the majority of robots and vehicles to locate with a really small margin of error
- Location recognition technology through precision map and GPS



GPS satellite



Road Features

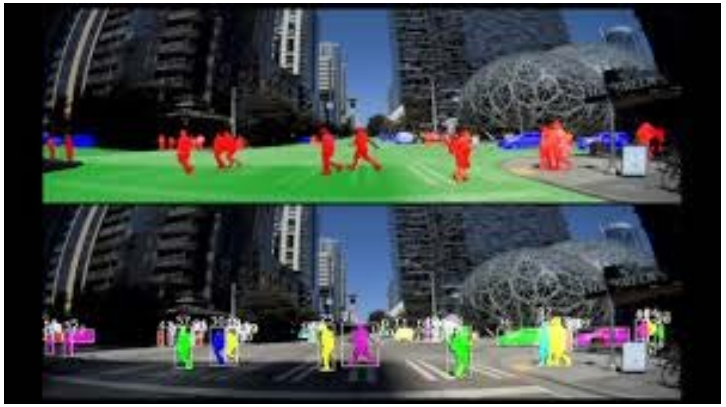


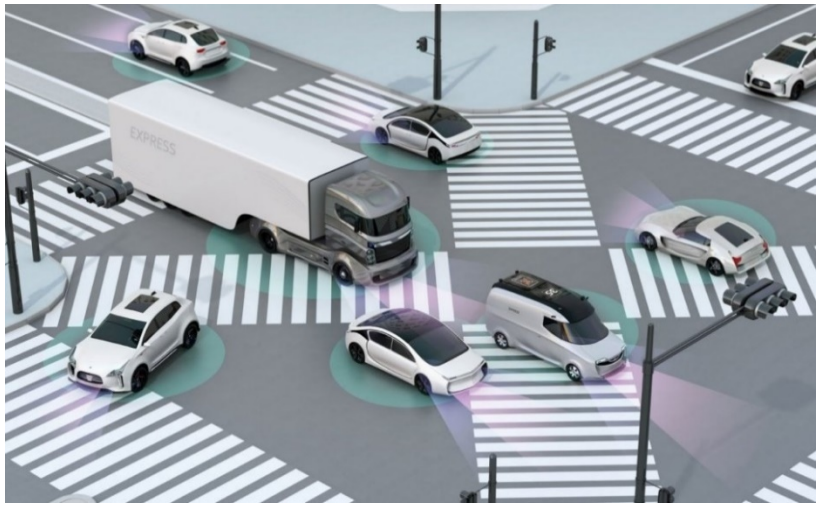
Precision Map

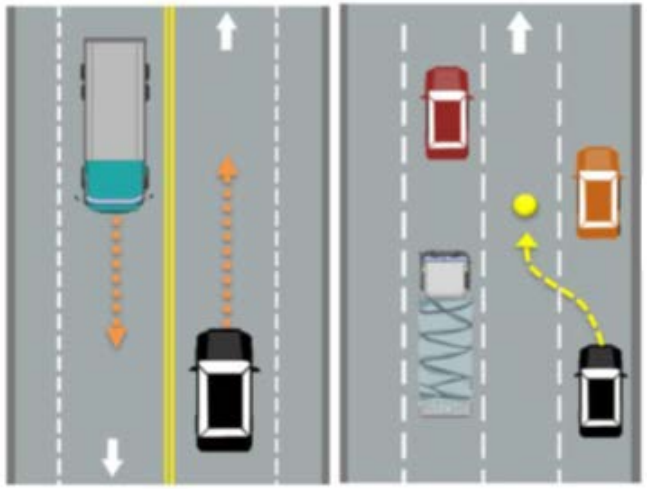
Perception (2)

Perception of Surroundings

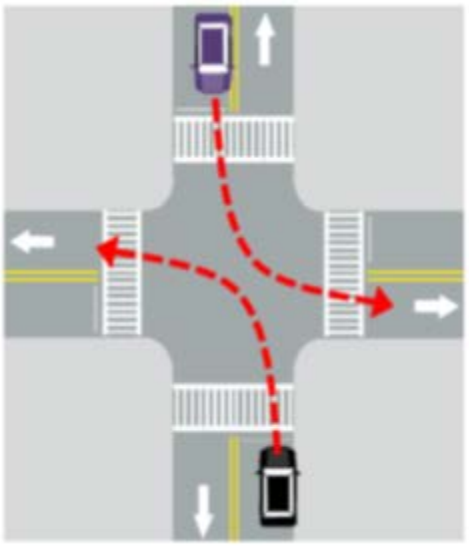
- Step to detect cars, pedestrians, lanes, traffic lights, traffic signs, etc. using information from various sensors
- Self-driving perception requires 100% accurate recognition of all information that a human driver perceives while driving





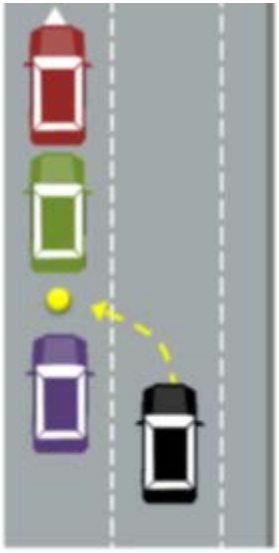


One lane driving Lane change

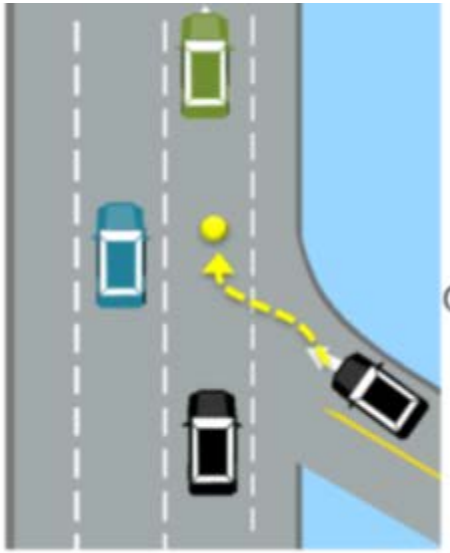


Left Turn

Road confluence



Cutting in line

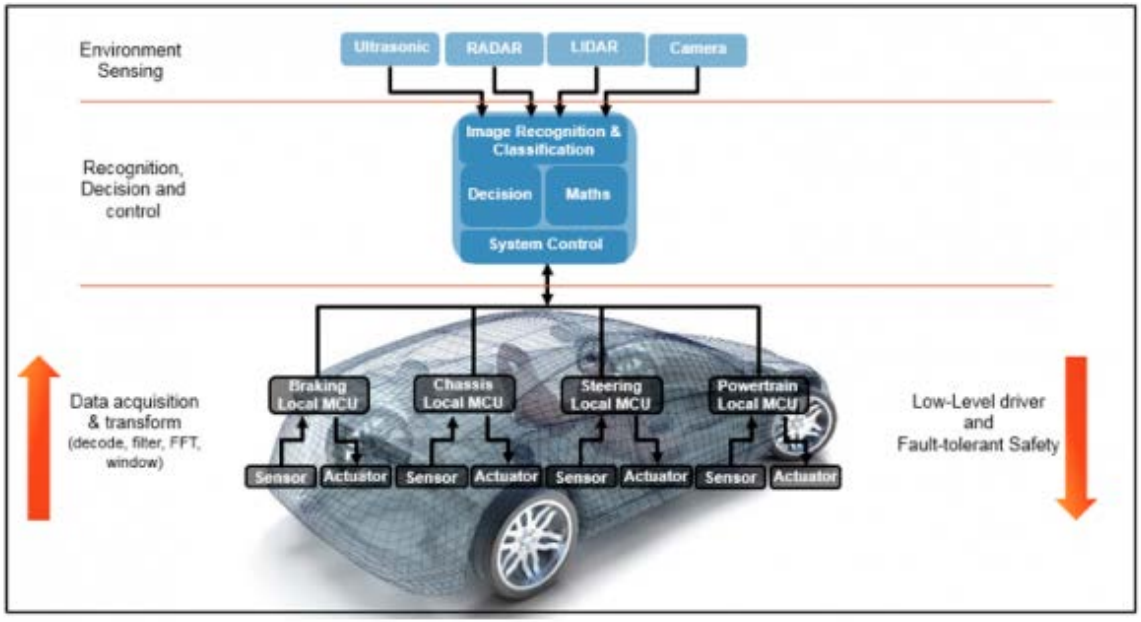


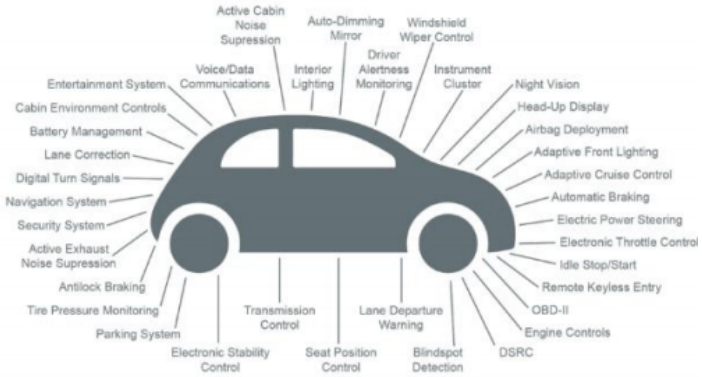
Highway access

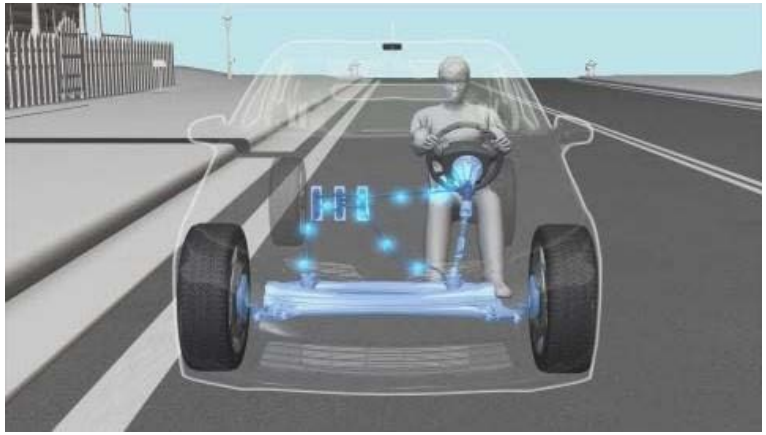
Crowded people

Control

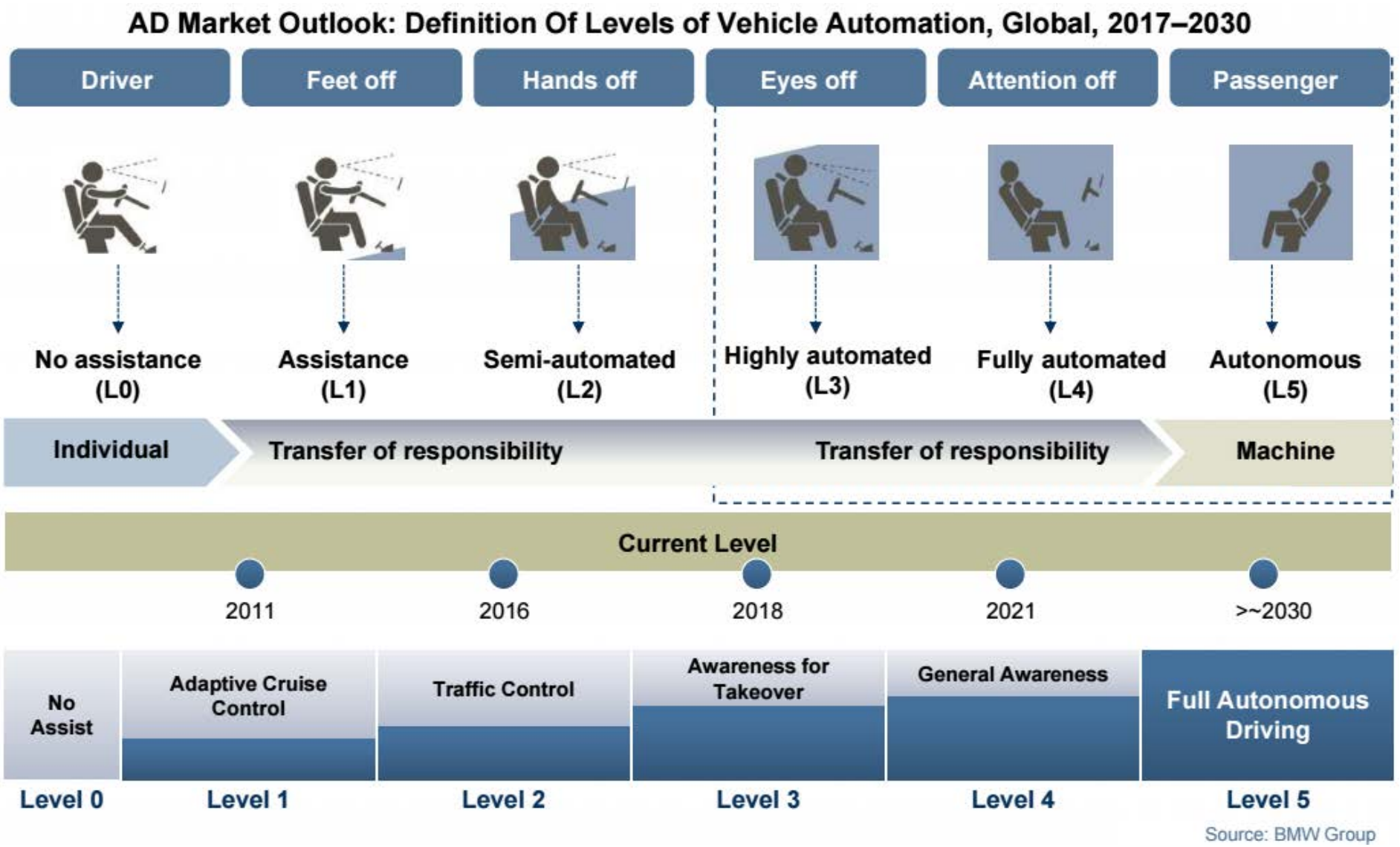
Application







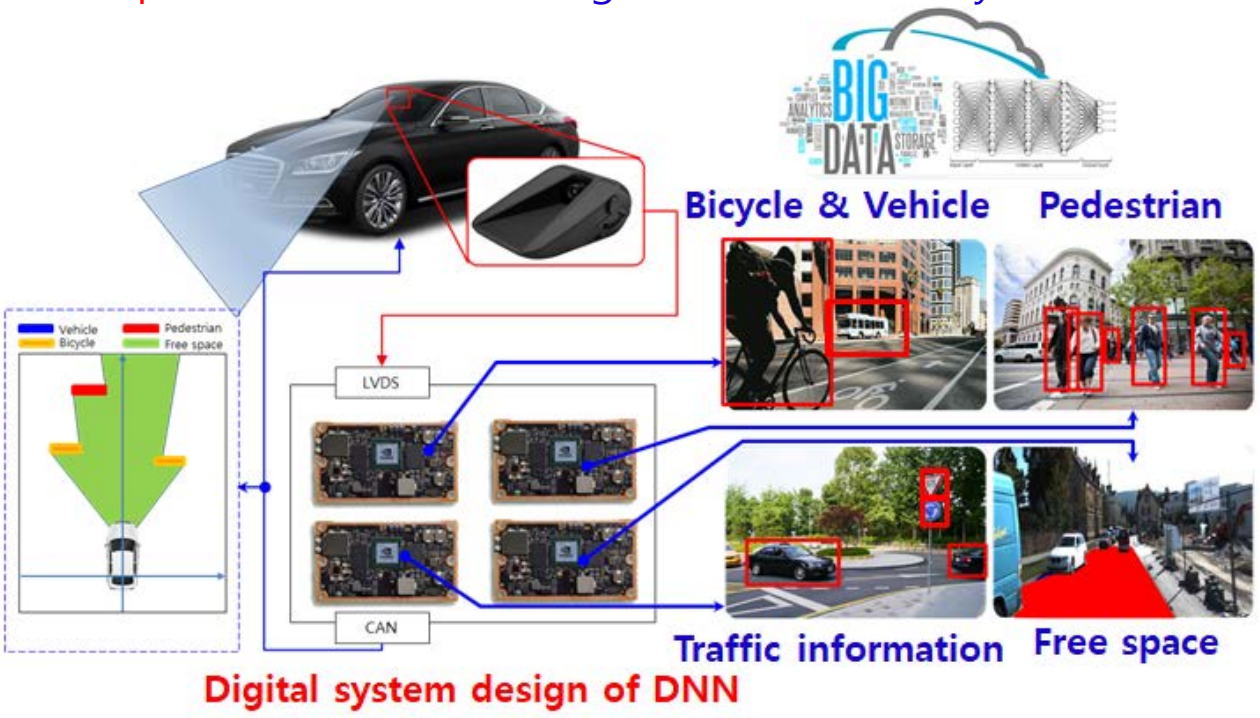
Levels of Autonomous Driving



Source: BMW Group

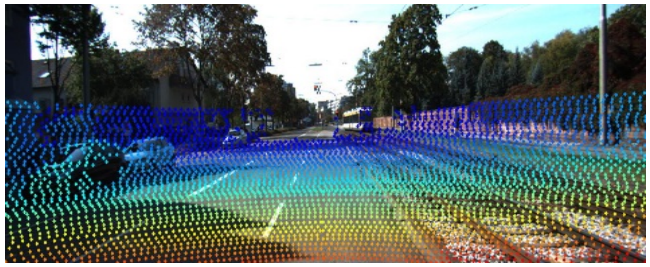
Autonomous Driving with DNN

- All researchers and companies have a plan to provide level 4 autonomous driving until 2025
- 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

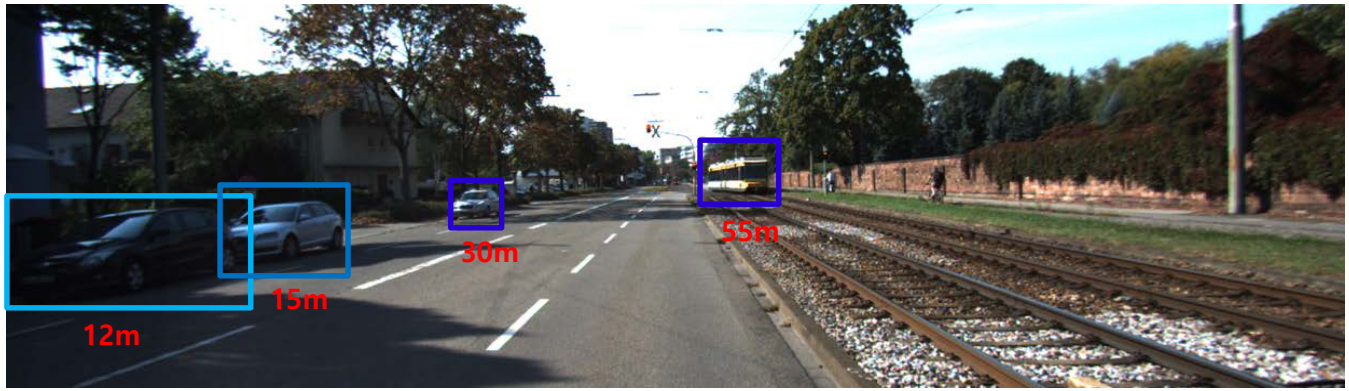


RGB camera Image

Lidar point cloud projected to 2d image

2-D Interpolation

Deep learning-based object detection using 4-channel images

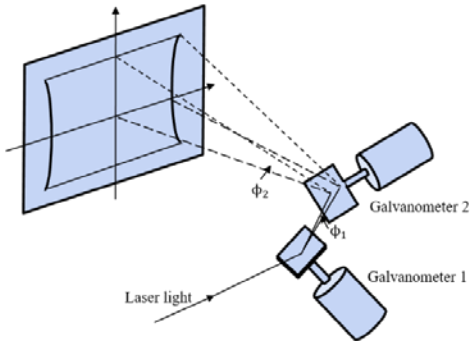


Project Leader of "Real-time mobile traffic information system based on multisensory fusion and integration"

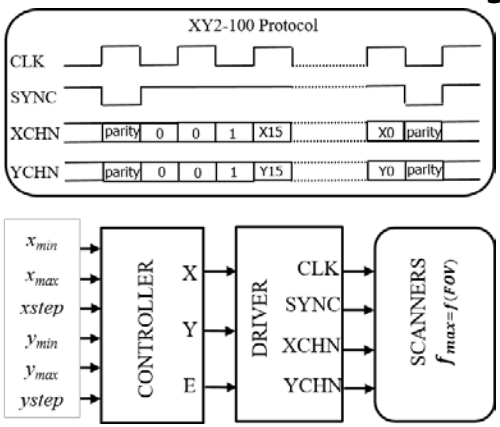
High-definition LiDAR system

◈ Goal : Implement a **high-definition LiDAR system**

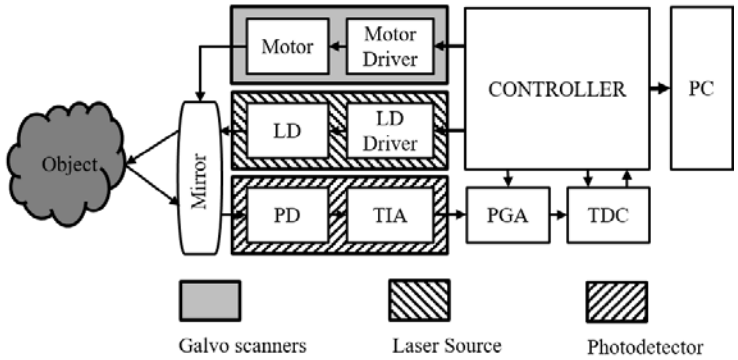
● Concept of the proposed scheme



● HW-based controller design



● Block diagram of the proposed LIDAR system



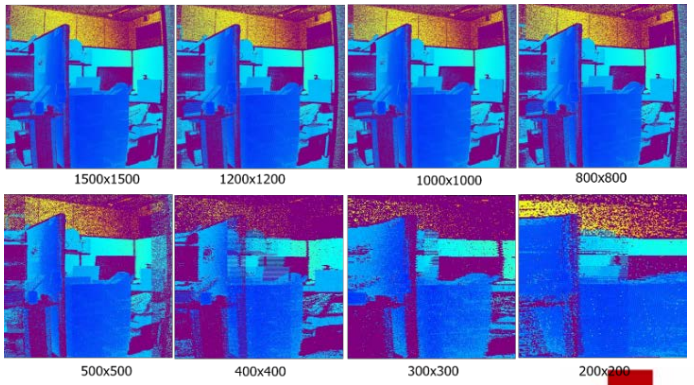
● Experimental results

FRAME RATES OVER DIFFERENT RESOLUTIONS OF AN ACQUIRED IMAGE

height	*width*	*FPS* by (15) (fps)	*FPS* by (16) (fps)	*Final FPS (fps)*
16	240	17.647	25.934	17.647
16	480	17.647	12.994	12.994
16	640	17.647	9.750	9.750
16	1280	17.647	4.879	4.879
32	240	9.091	12.967	9.091
32	480	9.091	6.497	6.497
32	640	9.091	4.875	4.875
32	1280	9.091	2.440	2.440
64	240	4.615	6.483	4.615
64	480	4.615	3.248	3.248
64	640	4.615	2.438	2.438
64	1280	4.615	1.220	1.220

FOV OVER DIFFERENT RESOLUTIONS OF AN ACQUIRED IMAGE

height	*width*	FOV_x		FOV_y	
		x_{max}	$angleX_{max}$	y_{max}	$angleY_{max}$
16	240	43,200	32.4°	2,880	**2.15°**
	480	60,000	45°		
	640	60,000	45°		
	1280	60,000	45°		
32	240	43,200	32.4°	5,760	**4.32°**
	480	60,000	45°		
	640	60,000	45°		
	1280	60,000	45°		
64	240	43,200	32.4°	11,520	**8.64°**
	480	60,000	45°		
	640	60,000	45°		
	1280	60,000	45°		



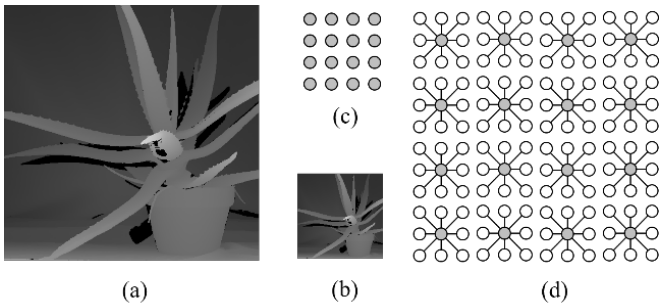
◈ Contribution

1) The HW-based controller modelling of scanners is derived
2) A prototype LiDAR system which achieves nearly 97,000 measurements per second while using only a single emitter/detector channel is developed

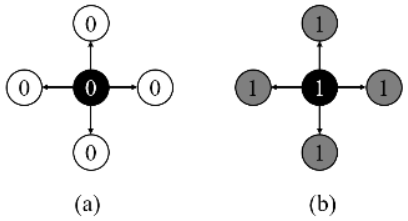
Efficient Sampling Algorithm for LiDAR

◈ Goal : Implement a low-complexity compressive sampling for depth data acquisition systems

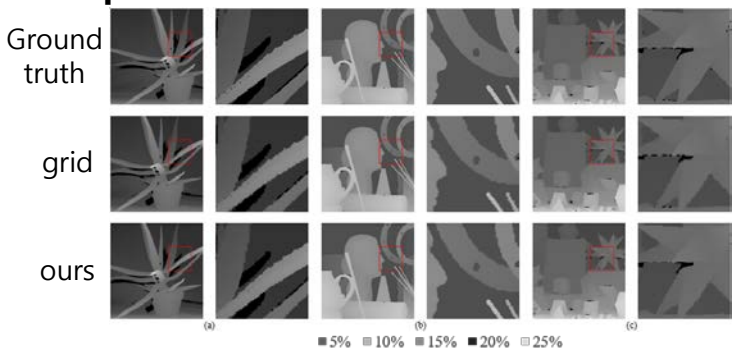
● **Concept**

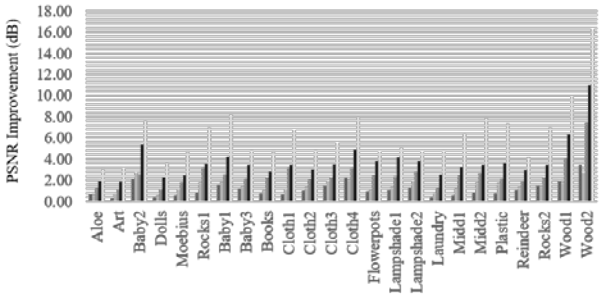


● **k-NN expanding operator**



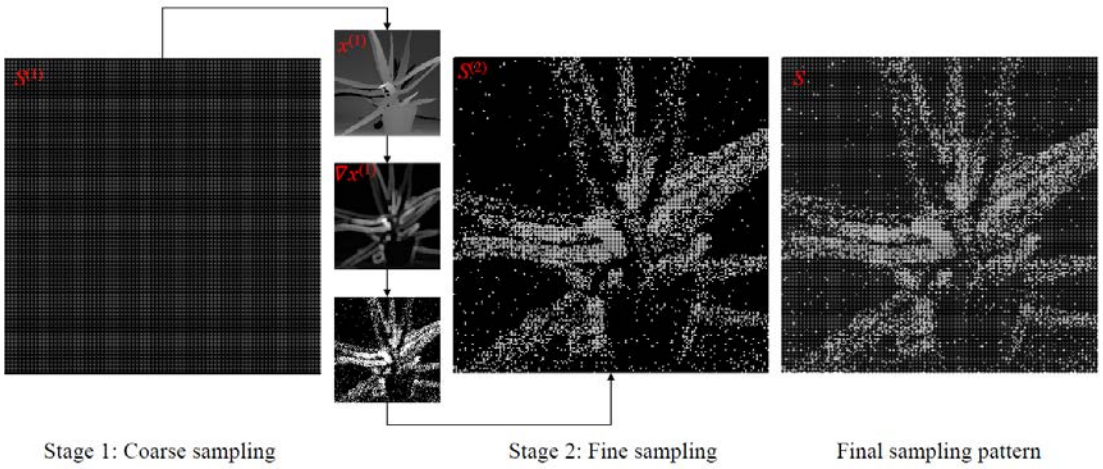
● **Experimental results**





Method	Target Compression Ratio								
	15%			20%			25%		
	min	max	average	min	max	average	min	max	average
Grid	28.51	41.33	32.48	29.17	41.95	33.93	29.90	42.57	33.93
[13] ideal	32.49	56.12	38.79	34.34	57.98	41.59	35.90	58.86	43.79
	3.98	14.80	6.31	5.16	16.03	7.67	6.00	16.29	9.86
[13] real	24.12	37.81	28.80	28.95	44.49	33.90	30.33	52.76	37.20
	-4.39	-3.52	-3.69	-0.22	2.54	-0.02	0.42	10.19	3.27
Ours	30.79	44.48	35.02	32.01	46.66	37.01	34.56	52.82	40.19
	2.28	3.15	2.54	2.84	4.72	3.08	4.66	10.25	6.27

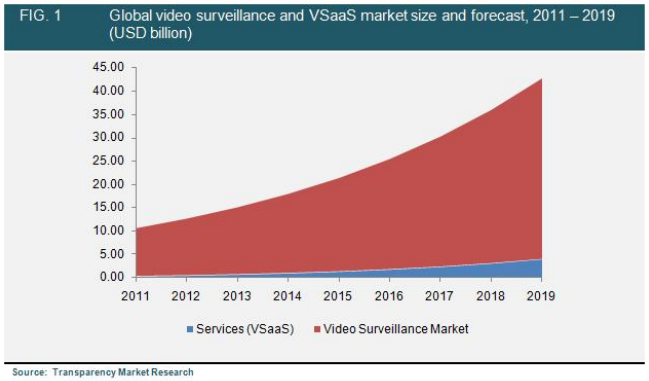
● **Flow of the proposed algorithm**



◈ Contribution

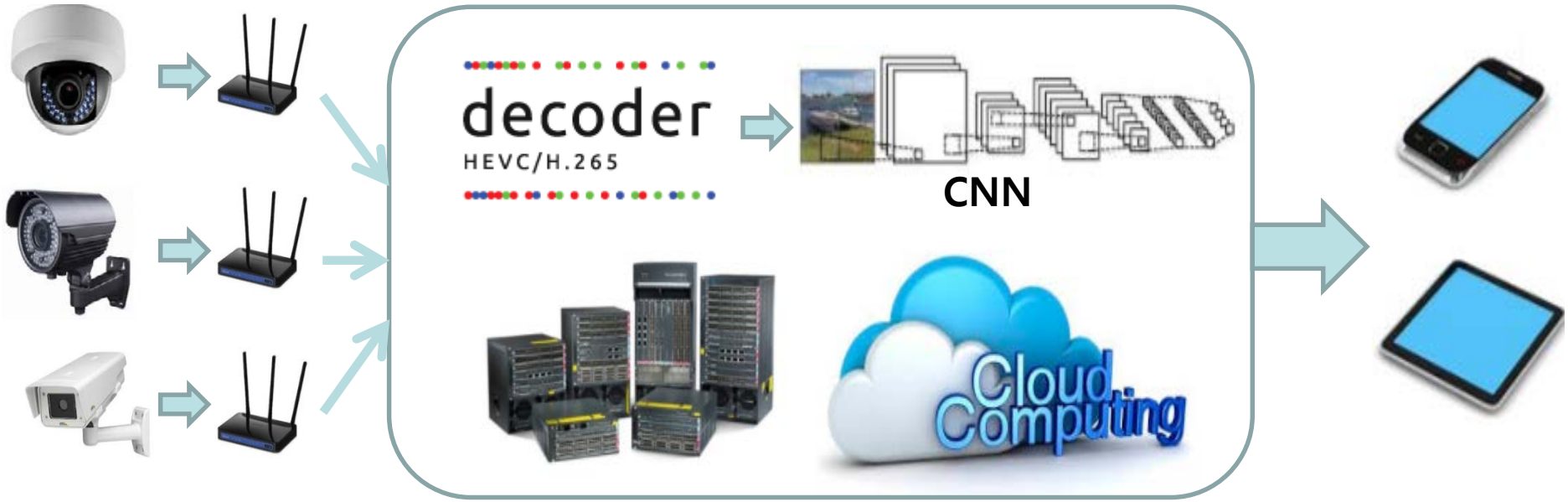
1) Extend the grid sampling and achieve $O(N)$ time-complexity for N pixels
2) Achieve a reconstruction quality similar to the state-of-art ones while operating much faster with less memory

Conventional VSaaS

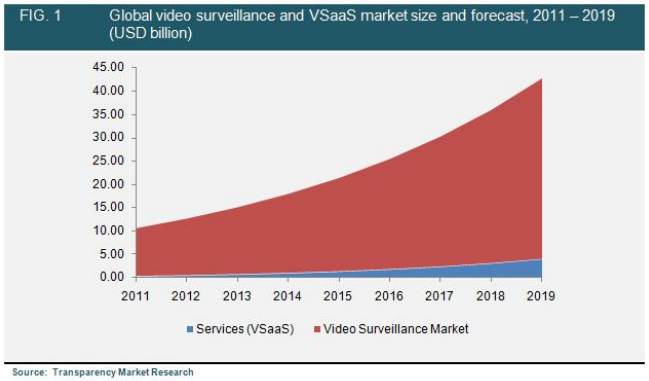


- DNN for Video Surveillance as a Service
- Application: Factory automation/Security/Smart silver care
- Advantage: Low cost, Maintenance, Scalability, Security, reusability of previous cameras
- Disadvantage: High complexity in a cloud system

Increase of VSaaS



Future VSaaS



Increase of VSaaS

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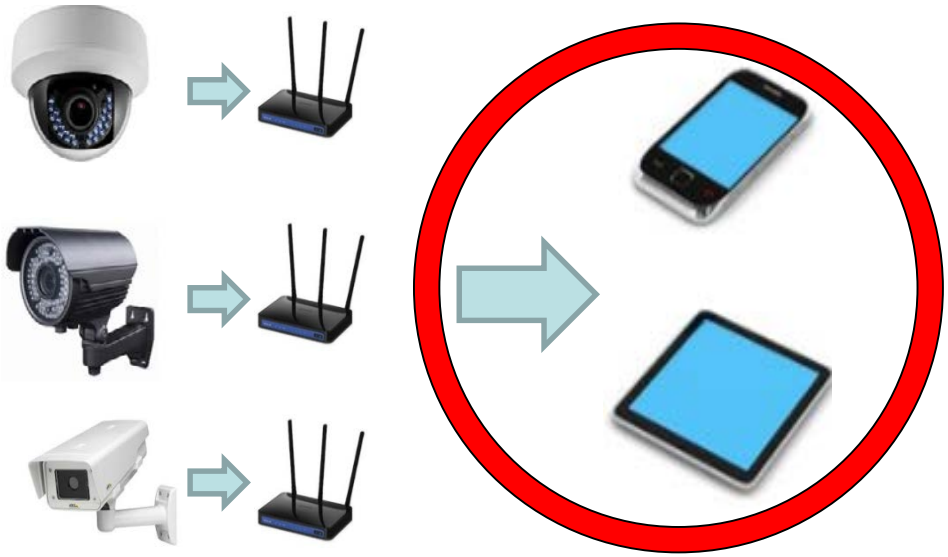
- Disadvantage: High complexity in a cloud system

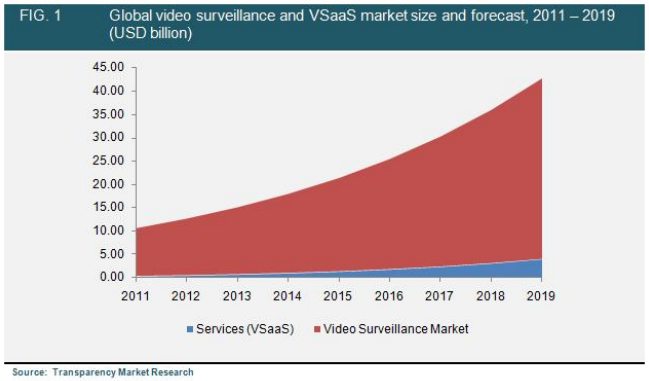
Deep learning at here!!



Edge Computing!!

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

Application : Smart Factory



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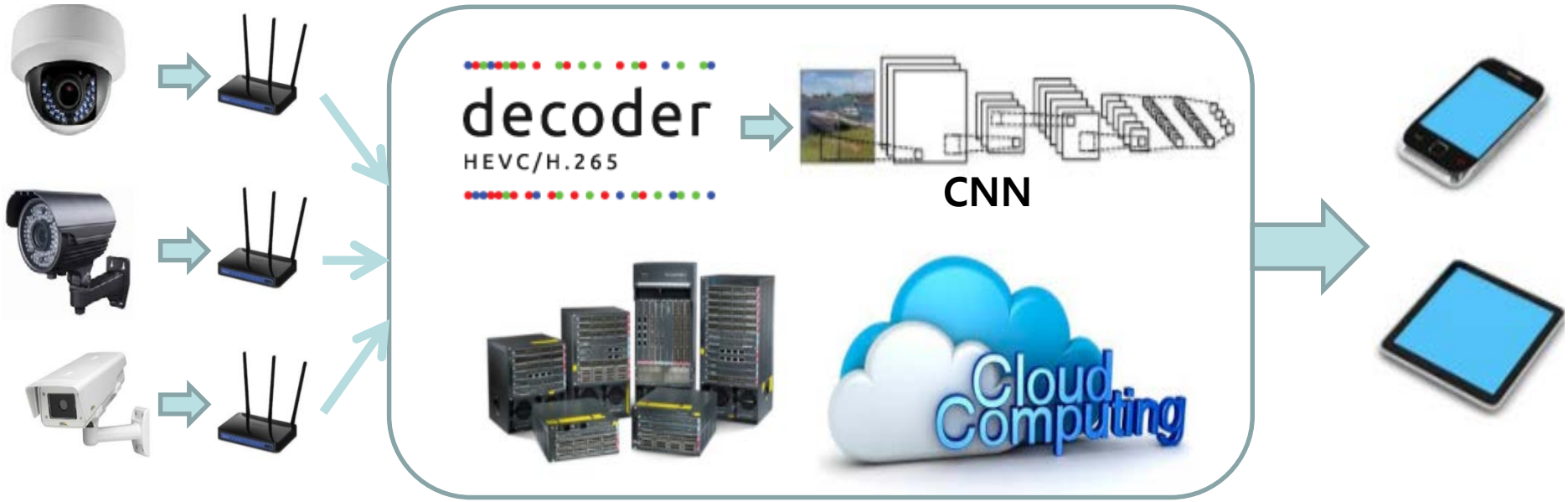
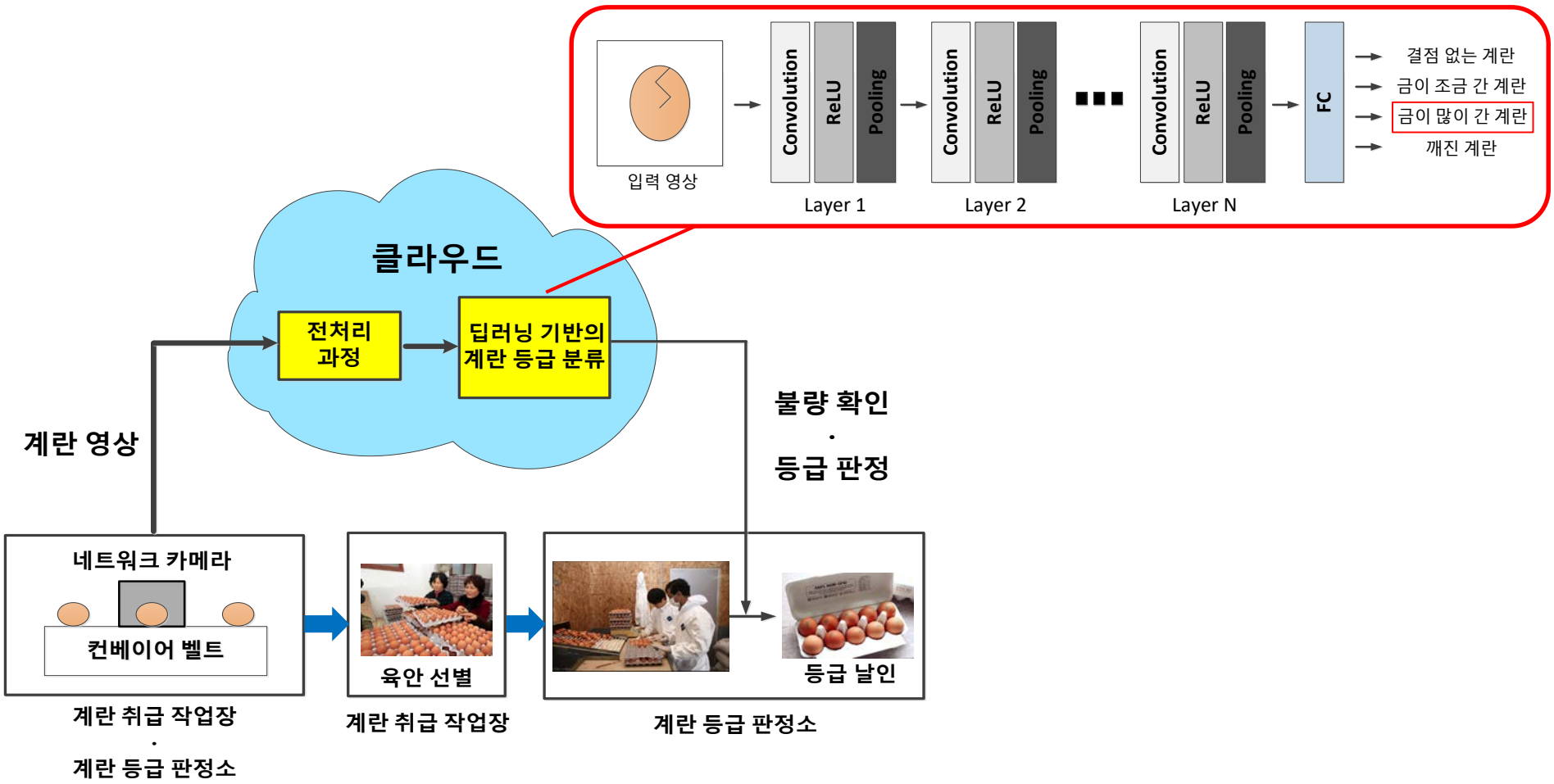
Increase of VSaaS



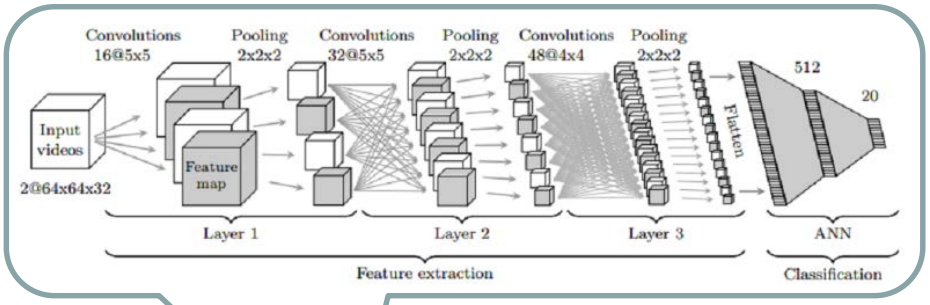
Application : Smart Factory

- 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



CNN

Cloud

Pre-Processing

Decoder

RoI Extraction

Fall detection / Gesture recognition based on DNN

PUSH

Gesture

IP Camera

Fall

Video P2P Transmission