The evolution of AI-based algorithms in automated driving SW components

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Safe and Dynamic Driving towards Vision Zero

SensePlanAct

Behind the scenes

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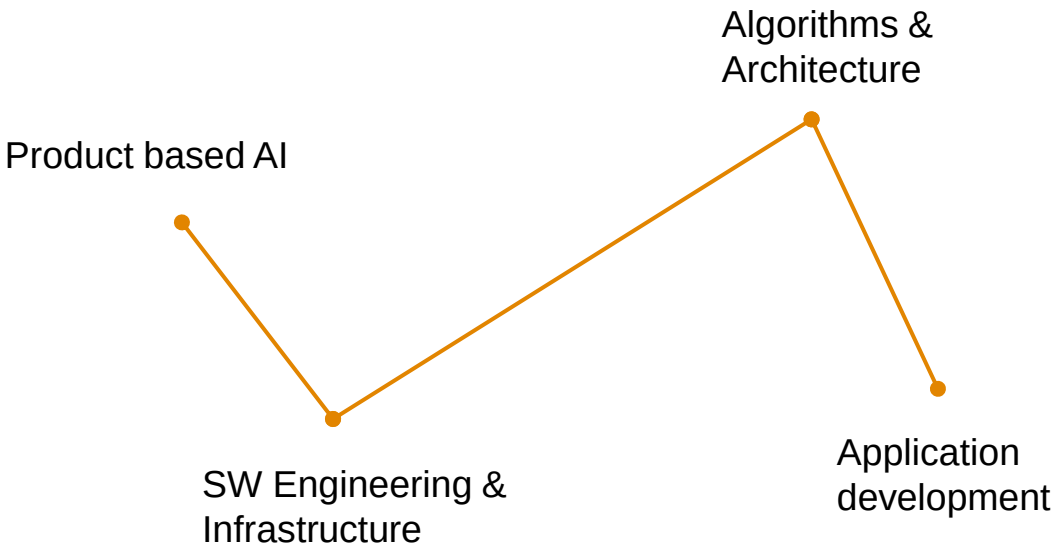
Automated Parking

Continental Autonomous Mobility Hungary



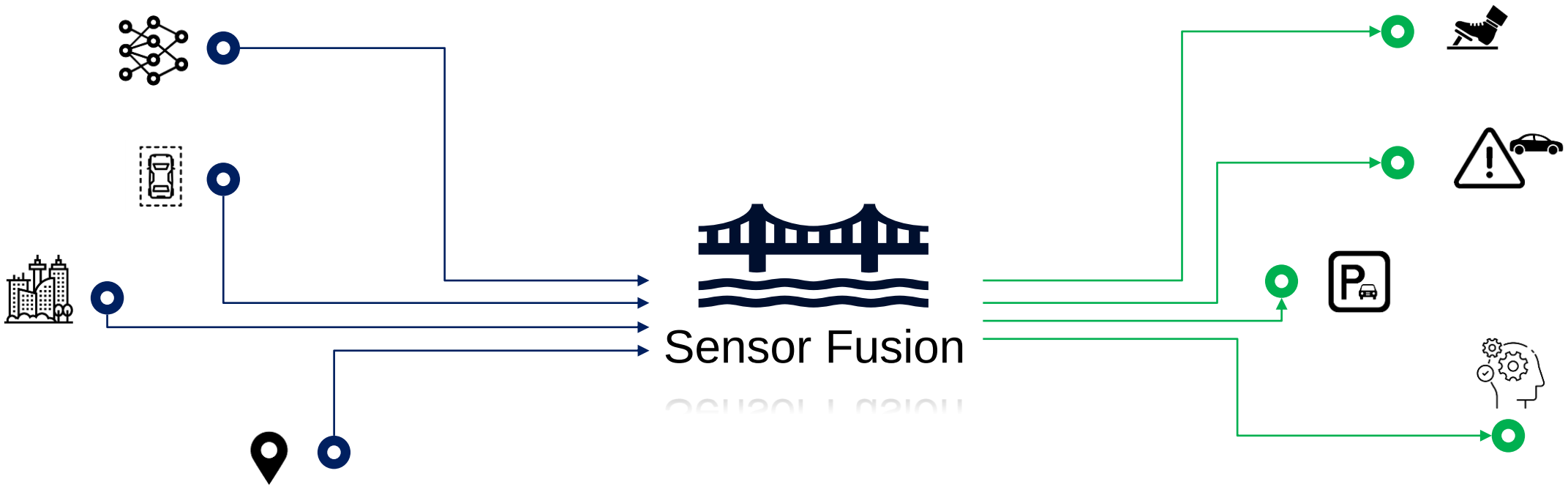
Levels of autonomy

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?	**You are driving** whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			**You are not driving** when these automated driving features are engaged – even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			**These are automated driving features**		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering **OR** brake/ acceleration support to the driver	These features provide steering **AND** brake/ acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering **OR** • adaptive cruise control	• lane centering **AND** • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/ steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

For a more complete description, please download a free copy of SAE J3016: https://www.sae.org/standards/content/j3016_201806/

Sensor Fusion: Gatekeeper or Bottleneck?

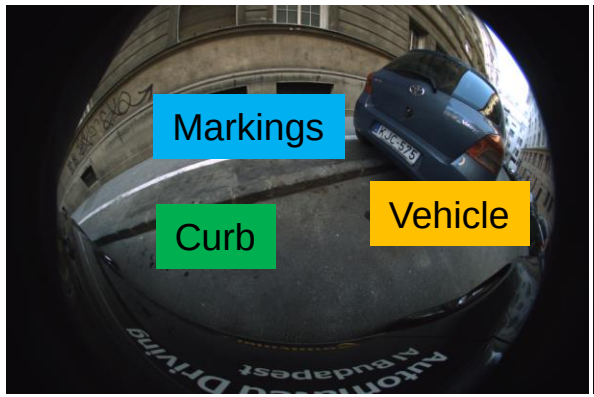


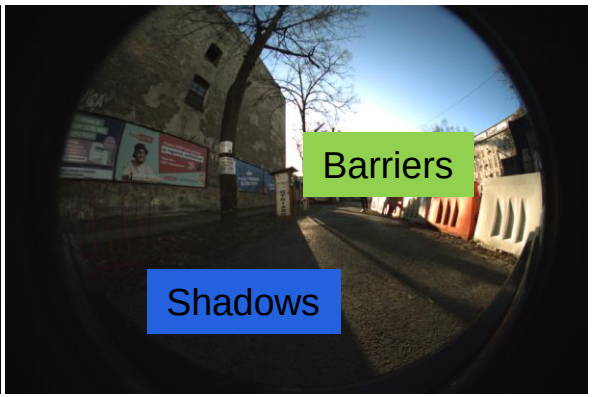
World perception

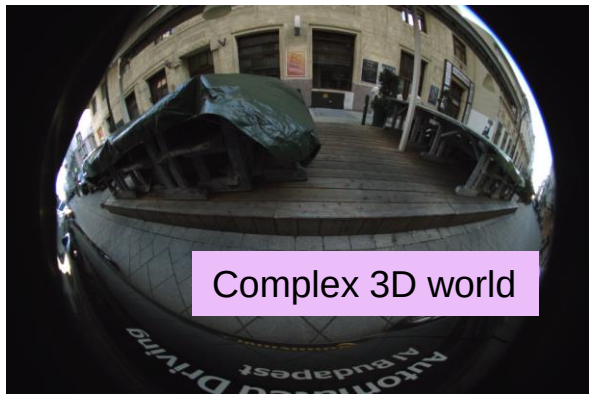
Driving functions

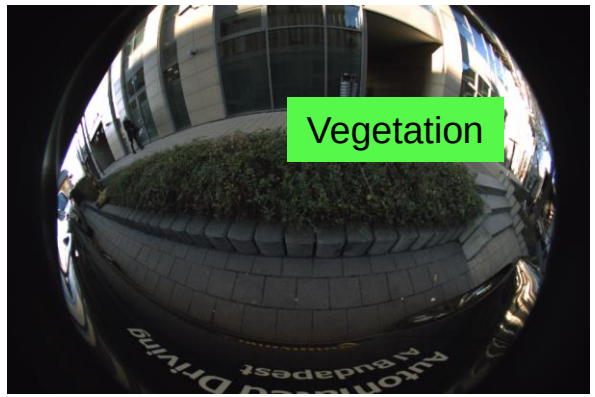

“Life begins at the end of your comfort zone.”
Neale Donald Walsch

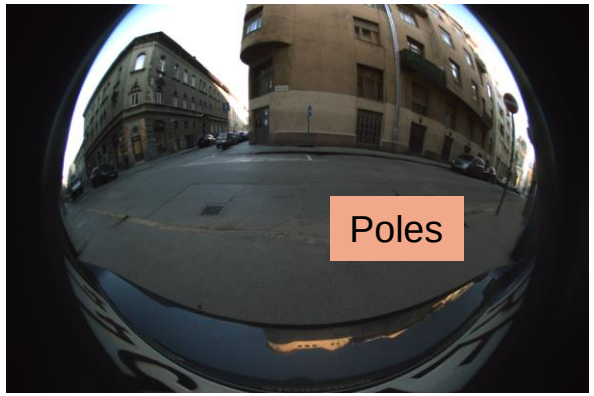
Colorful world

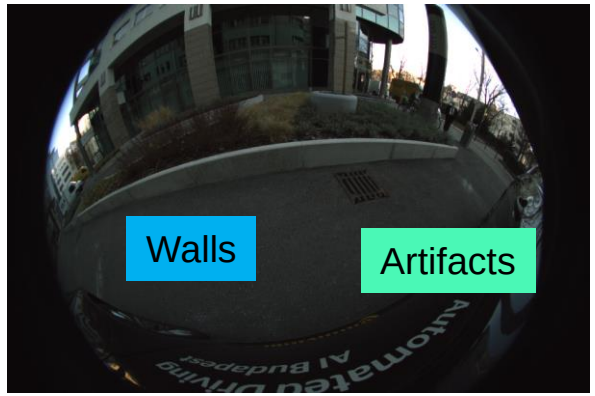






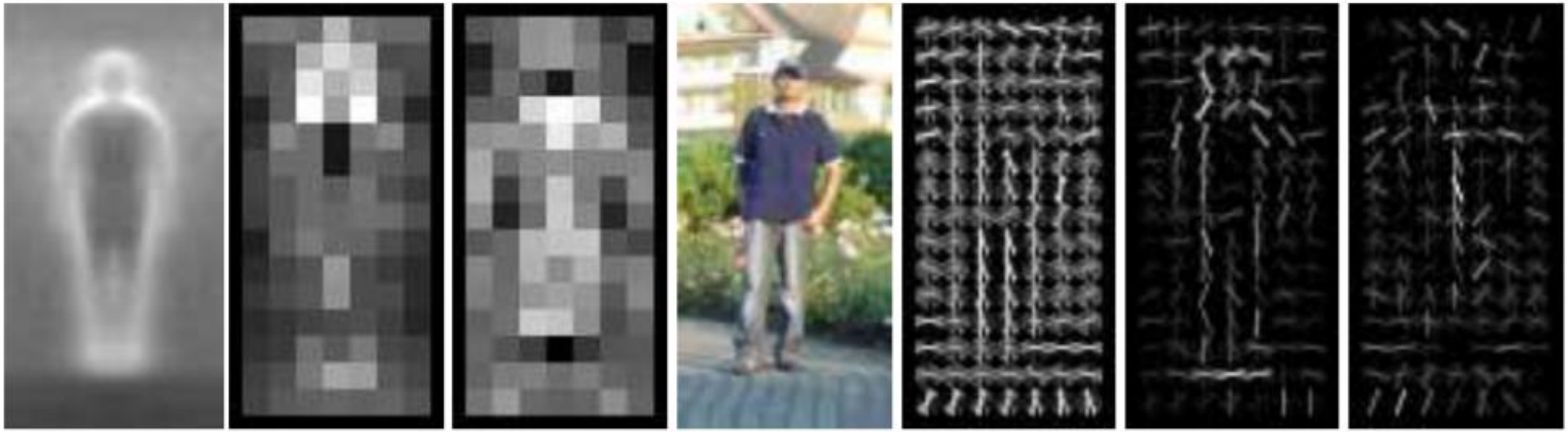






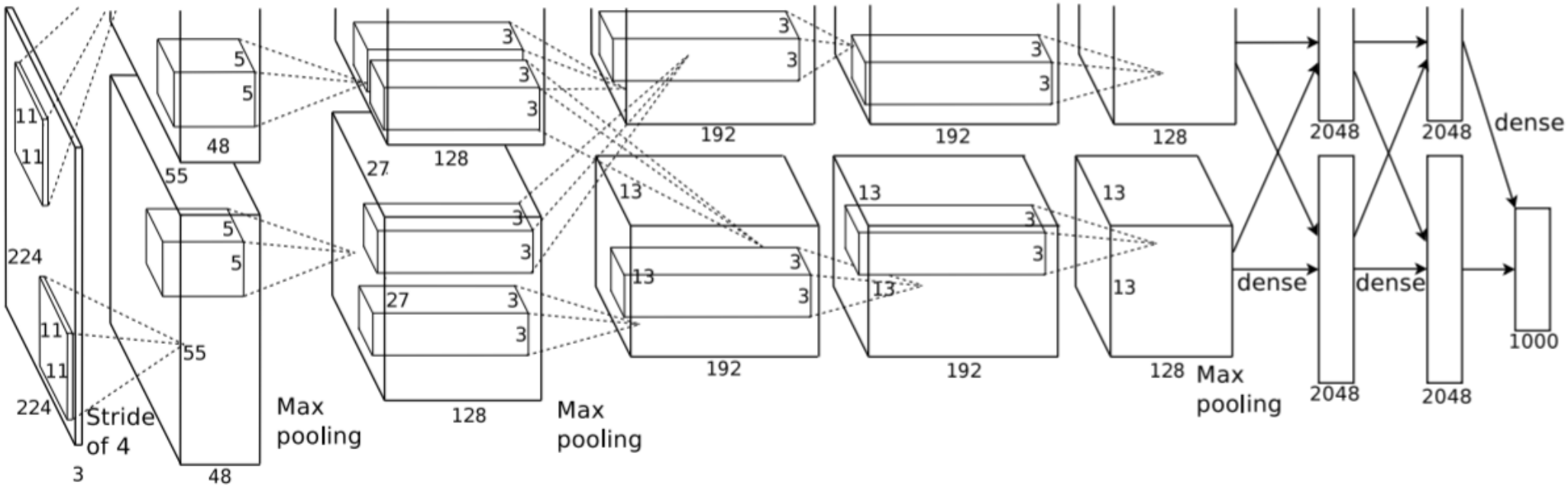

Lane Change ahead
120
80
INFORMATION
80
Driving Functions
Cruising Functions
Maneuvering Functions
Safety Bundle
Traffic Jam Assist
Steering Assist
16:25:53
Gear Head
The Blacks
6. The destination will finally come

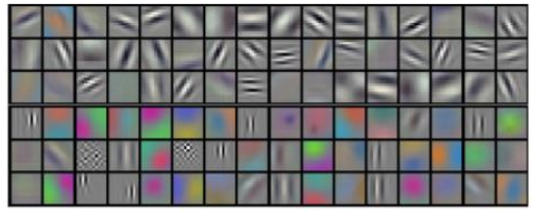
Analysis – old times



Dalal, Navneet, and Bill Triggs. "Histograms of oriented gradients for human detection." *2005 IEEE computer society conference on computer vision and pattern recognition (CVPR'05)*. Vol. 1. Ieee, 2005.

Synthesis – the new era





Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E. Hinton. "Imagenet classification with deep convolutional neural networks." Advances in neural information processing systems 25 (2012): 1097-1105.

Common perception modules in self-driving

Low-speed maneuvering

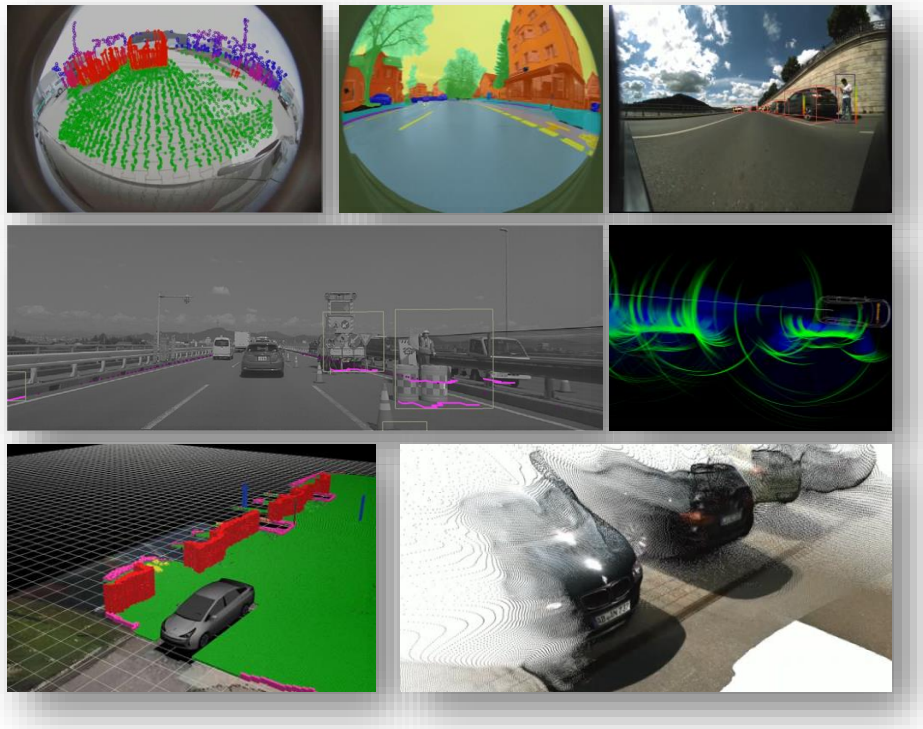
Surround view

Radar belts

Markings and curbs

Collision avoidance

Memory parking



High-speed maneuvering

Front vision

Long range radar applications

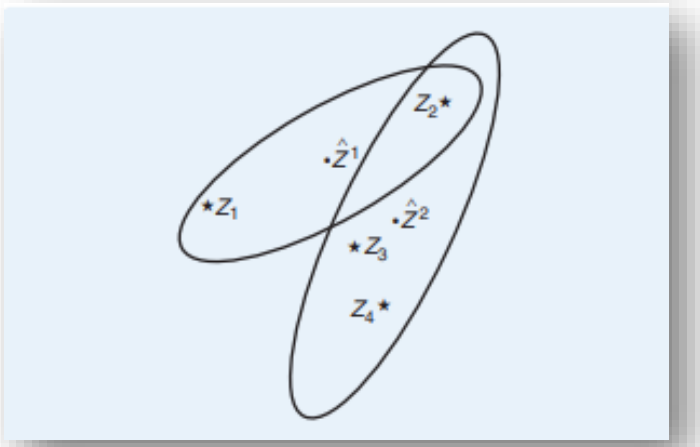
Lane detection

Emergency Break Assist

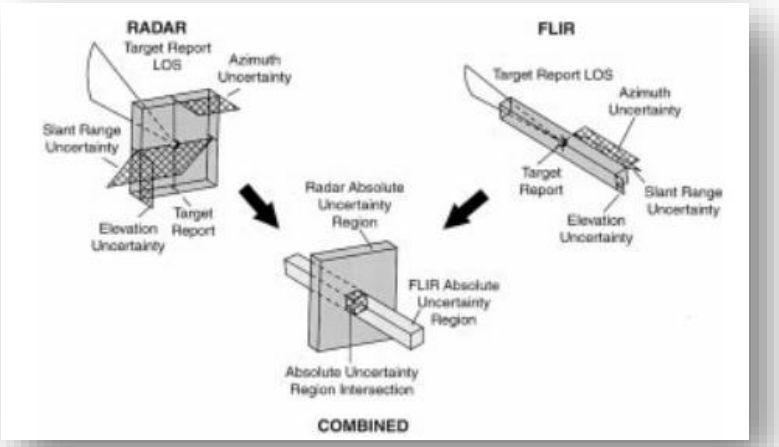
HD maps

Highest levels of autonomy in complex scenarios

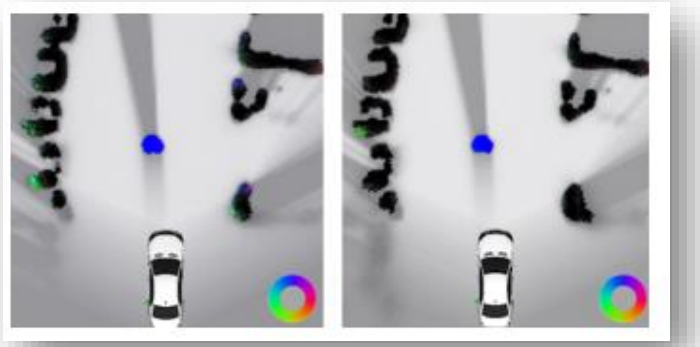
Evolution of environment modeling



Bar-Shalom, Yaakov, Fred Daum, and Jim Huang. "The probabilistic data association filter." IEEE Control Systems Magazine 29.6 (2009): 82-100.



Hall, David L., and James Llinas. "An introduction to multisensor data fusion." Proceedings of the IEEE 85.1 (1997): 6-23.



Nuss, Dominik, et al. "A random finite set approach for dynamic occupancy grid maps with real-time application." The International Journal of Robotics Research 37.8 (2018): 841-866.

Lim, Teck-Yian, et al. "Radar and camera early fusion for vehicle detection in advanced driver assistance systems." *Machine learning for autonomous driving workshop at the 33rd conference on neural information processing systems*. Vol. 2. 2019.

It’s all about balance

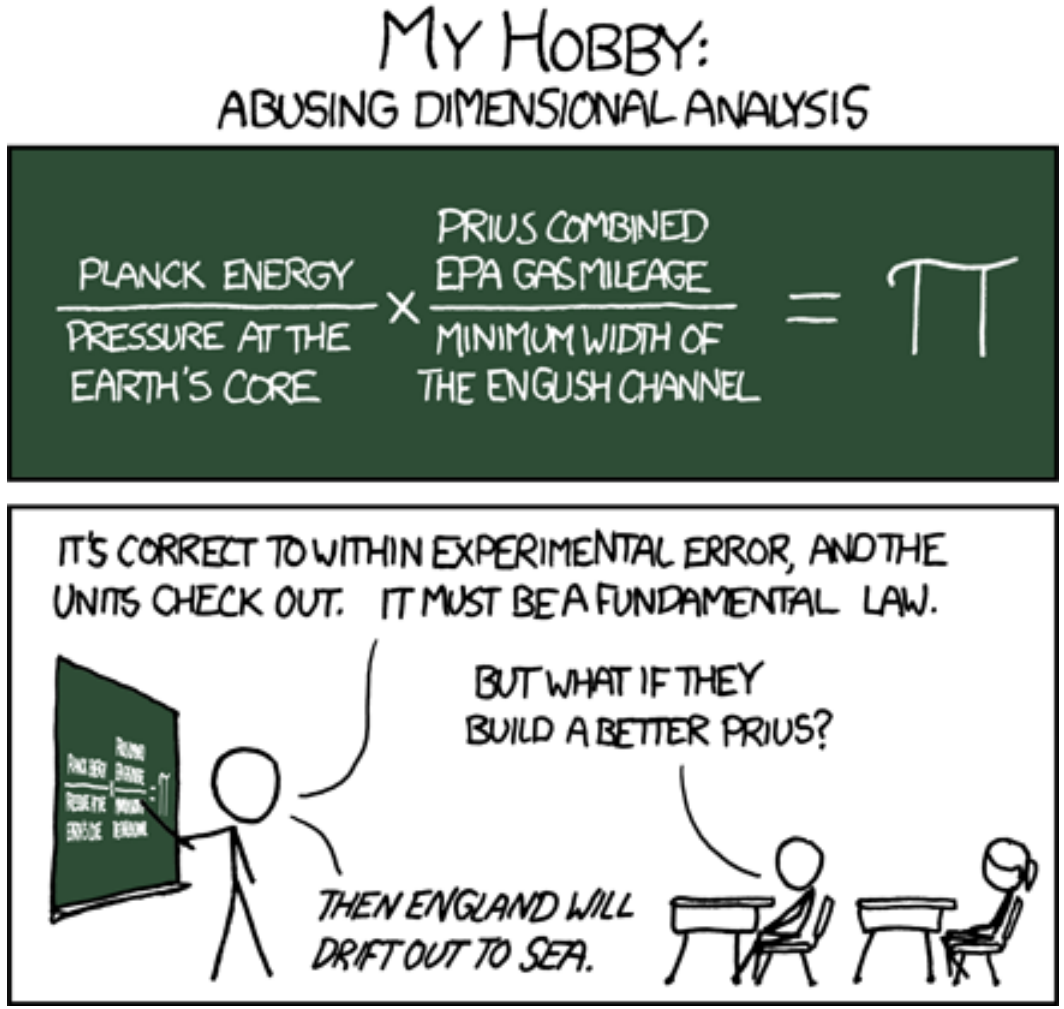


Image credit: https://xkcd.com/687/

Broadening the competence

SW Engineering

Deep Learning

Automotive Processes

Embedded Optimization

SW Architecture

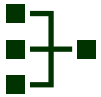
Low level fusion vs. High level fusion

Divide & Conquer

Optimize for development

Task definition

Coordinate collaboration

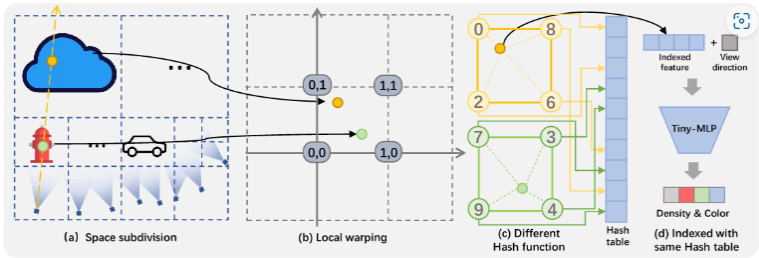


System complexity

Visualize and comprehend

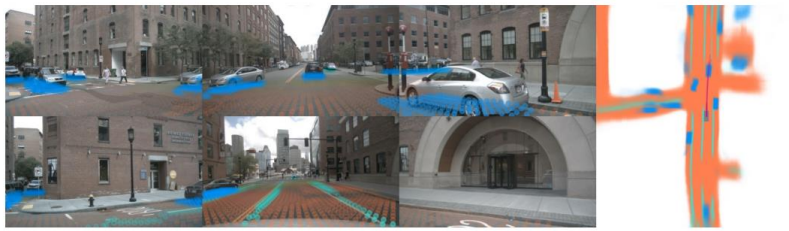
What’s next for (AI-based) environment modeling?

Neural Radiance Field Training (NeRF)



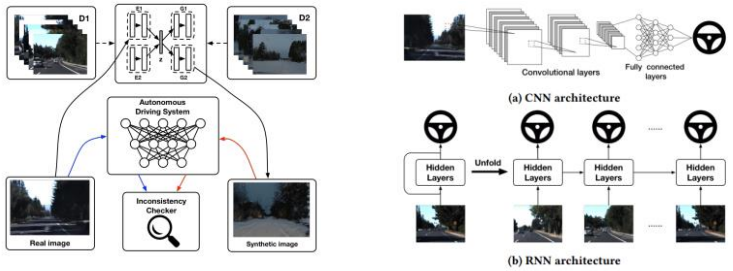
Wang, Peng, et al. "F $^{2} $-NeRF: Fast Neural Radiance Field Training with Free Camera Trajectories." *arXiv preprint arXiv:2303.15951* (2023).

Bird’s-Eye-View (BEV) networks



Philion, Jonah, and Sanja Fidler. "Lift, splat, shoot: Encoding images from arbitrary camera rigs by implicitly unprojecting to 3d." *Computer Vision–ECCV 2020: 16th European Conference, Glasgow, UK, August 23–28, 2020, Proceedings, Part XIV 16*. Springer International Publishing, 2020.

Generative models (GAN)



Zhang, Mengshi, et al. "DeepRoad: GAN-based metamorphic testing and input validation framework for autonomous driving systems." *Proceedings of the 33rd ACM/IEEE International Conference on Automated Software Engineering*. 2018.

Key takeaways

Sensor fusion: the gatekeeper of perception

Balance is key between AI and classical methods

Synergy grows among competence fields

Safe and Dynamic Driving
towards Vision Zero

SensePlanAct

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