

Autonomous Vehicle Perception - From Research to Production

Content

- Object detection
- Model development impressions
- Autonomous driving complexity
- AI in practice
- Imminent challenges AV industry

Hands-on coding



My path to autonomous driving

driveblocks

- 2011-2015: Mech. Eng. Bachelor TUM
- 2013: Exchange to UP Valencia

- 2015-2017: Mech. Eng. Master TUM
- 2017: Master thesis UC Berkeley

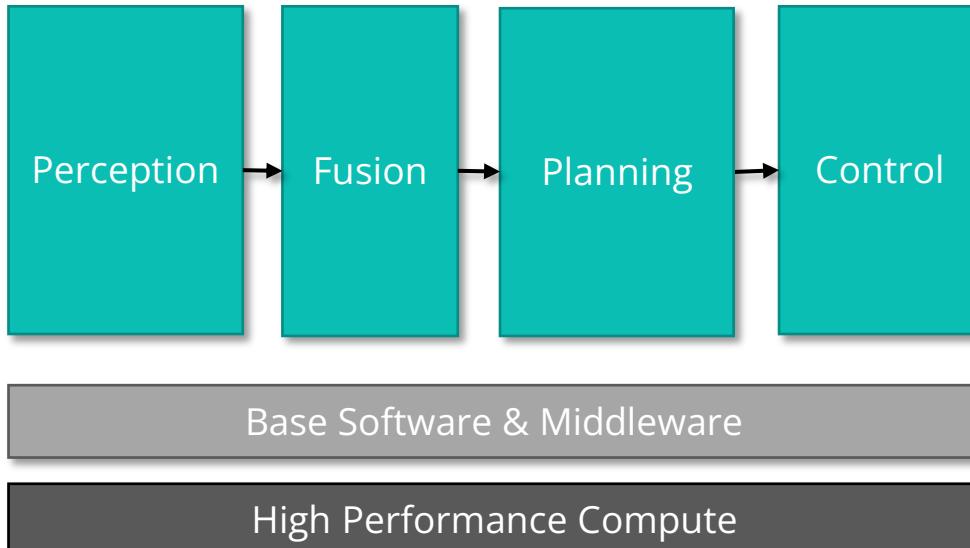
- 2017-2021: Ph.D. TUM

- 01/2022: Co-founder driveblocks



Object detection

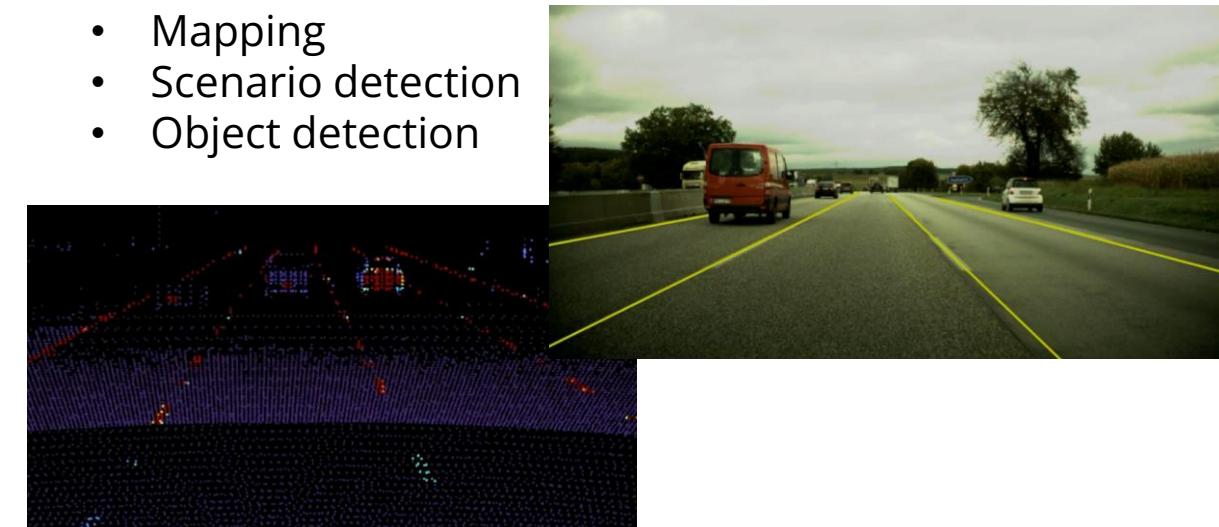
AV software stack



Perception & AI

Deep Learning

- Free-space detection
- Traffic-sign detection
- Localization
- Mapping
- Scenario detection
- Object detection



Camera



Lidar



Radar

Image Classification



container ship

container ship

lifeboat

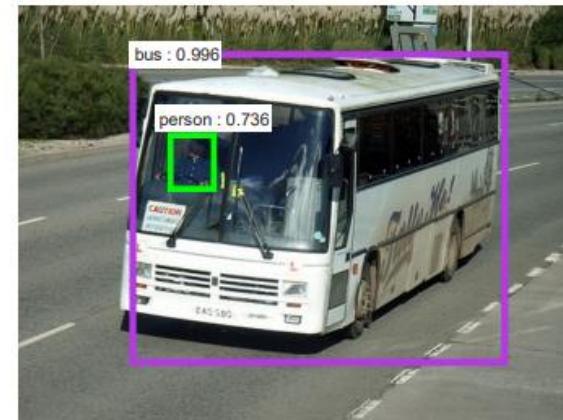
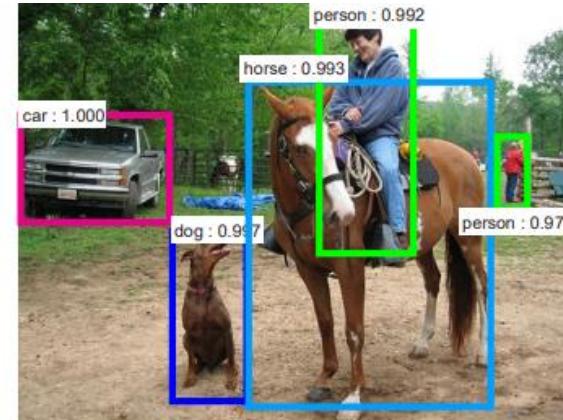
amphibian

fireboat

drilling platform

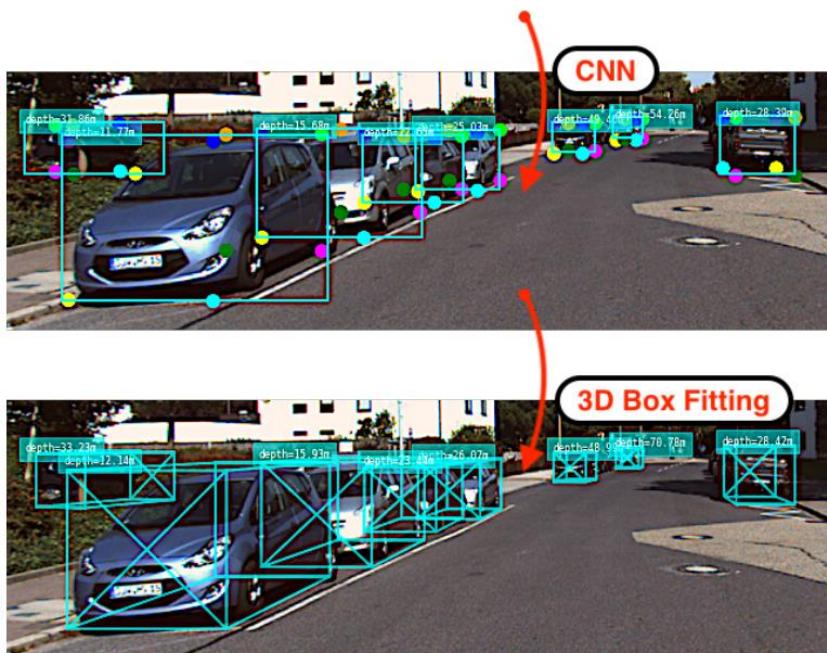
AlexNet [Kri12]

2D Object Detection



Faster RCNN [Ren15]

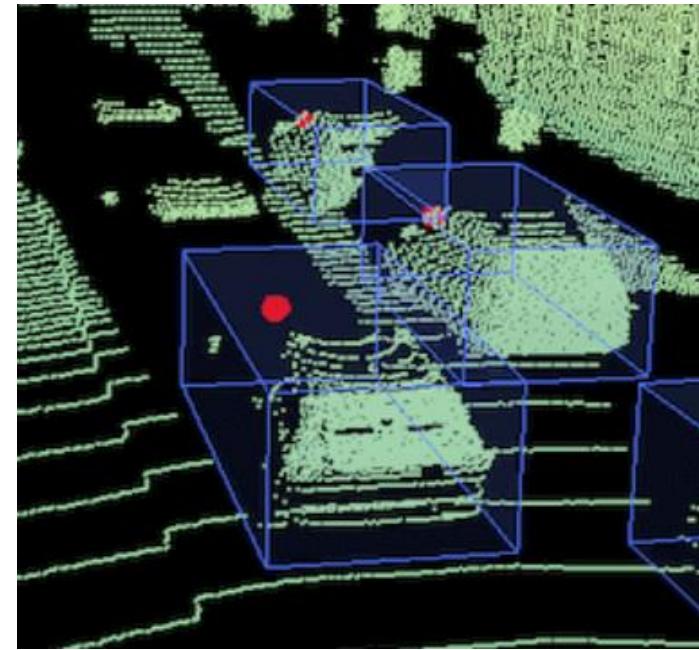
Camera Object Detection



Mono3D [Jör19]

Camera Problem:
No depth information in images

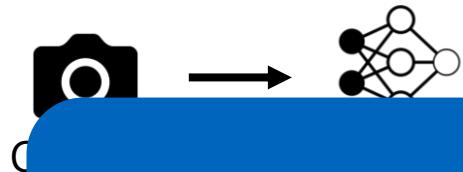
Lidar Object Detection



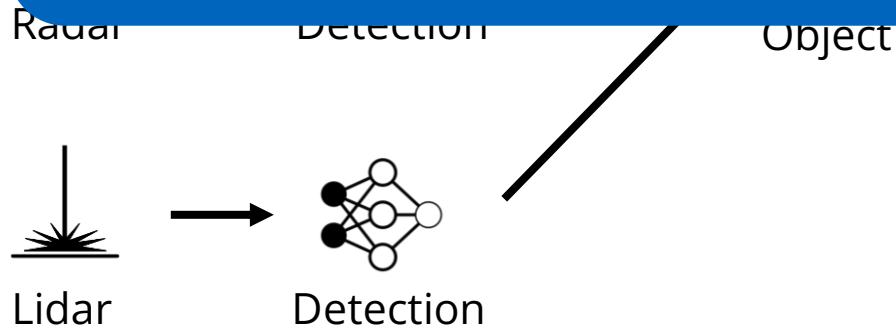
VoxelNet [Zho17]

Lidar:
ca. 8x Performance vs. Camera on KITTI

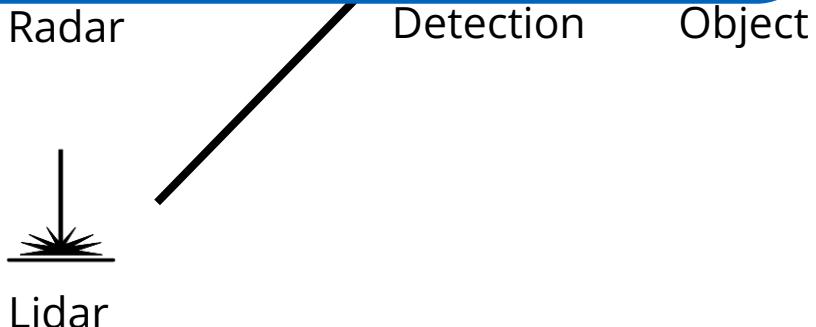
High-Level Sensor Fusion

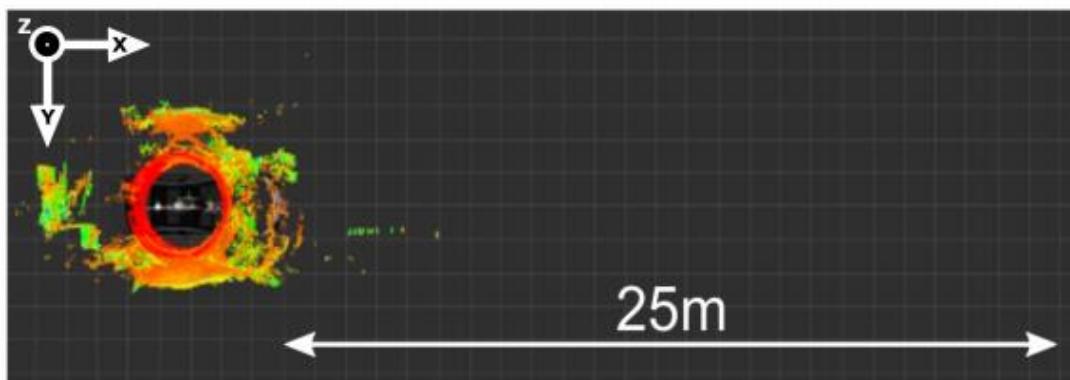
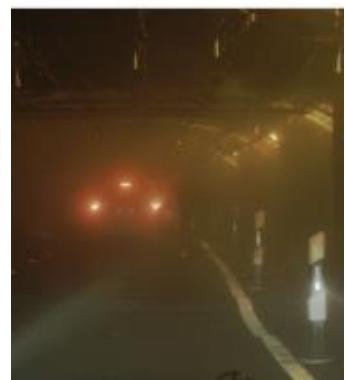
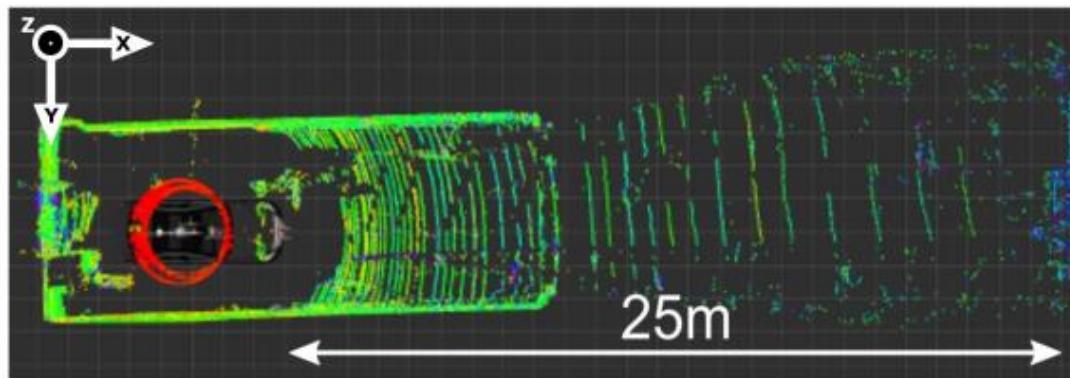


Validation & Verification requirements like ISO 26262:
Need for fusion in production systems for safety & robustness!

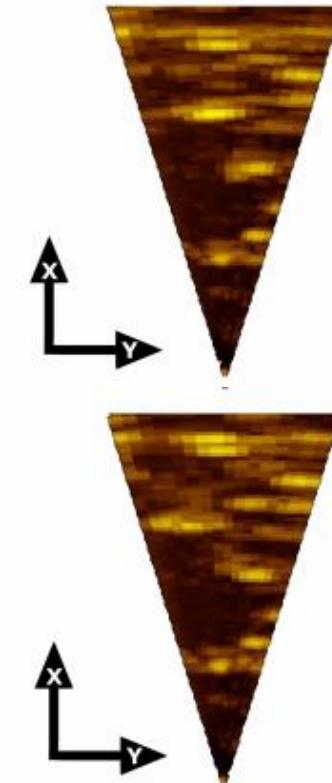


Low-Level Sensor Fusion





Lidar only detects fog.



Radar is robust to fog.

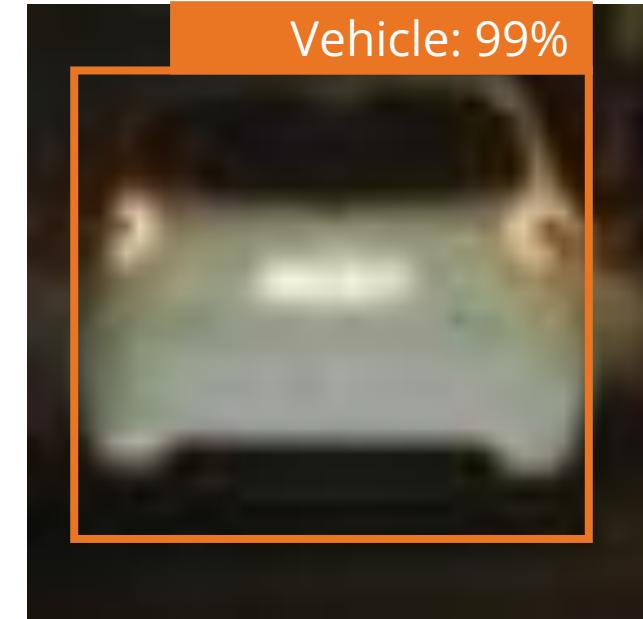
[Bij19]

Camera Object Detection



[Bij19]

Obtainable Result



Camera Object Detection



[Bij19]

Obtainable Result



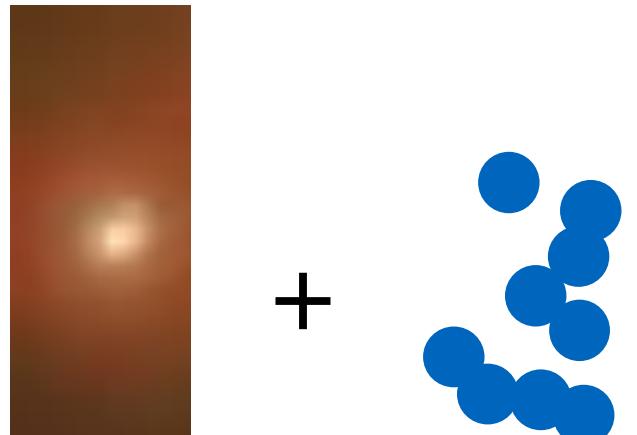
Camera Object Detection



Obtainable Result



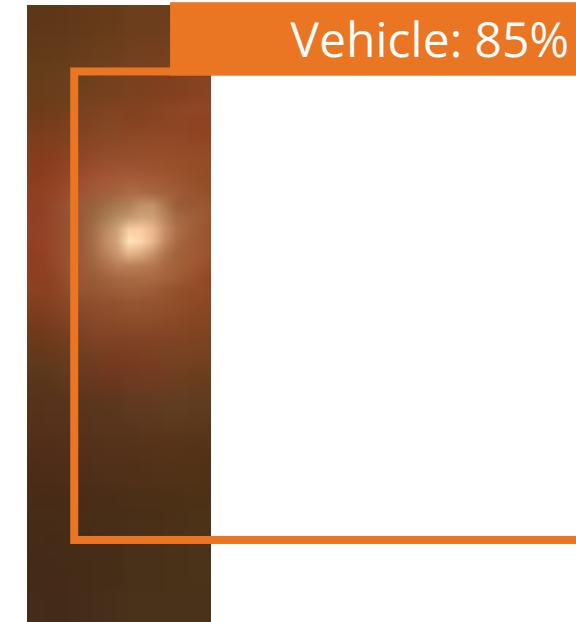
Low-Level Sensor Fusion



Camera
Weak feature

Radar
Weak feature

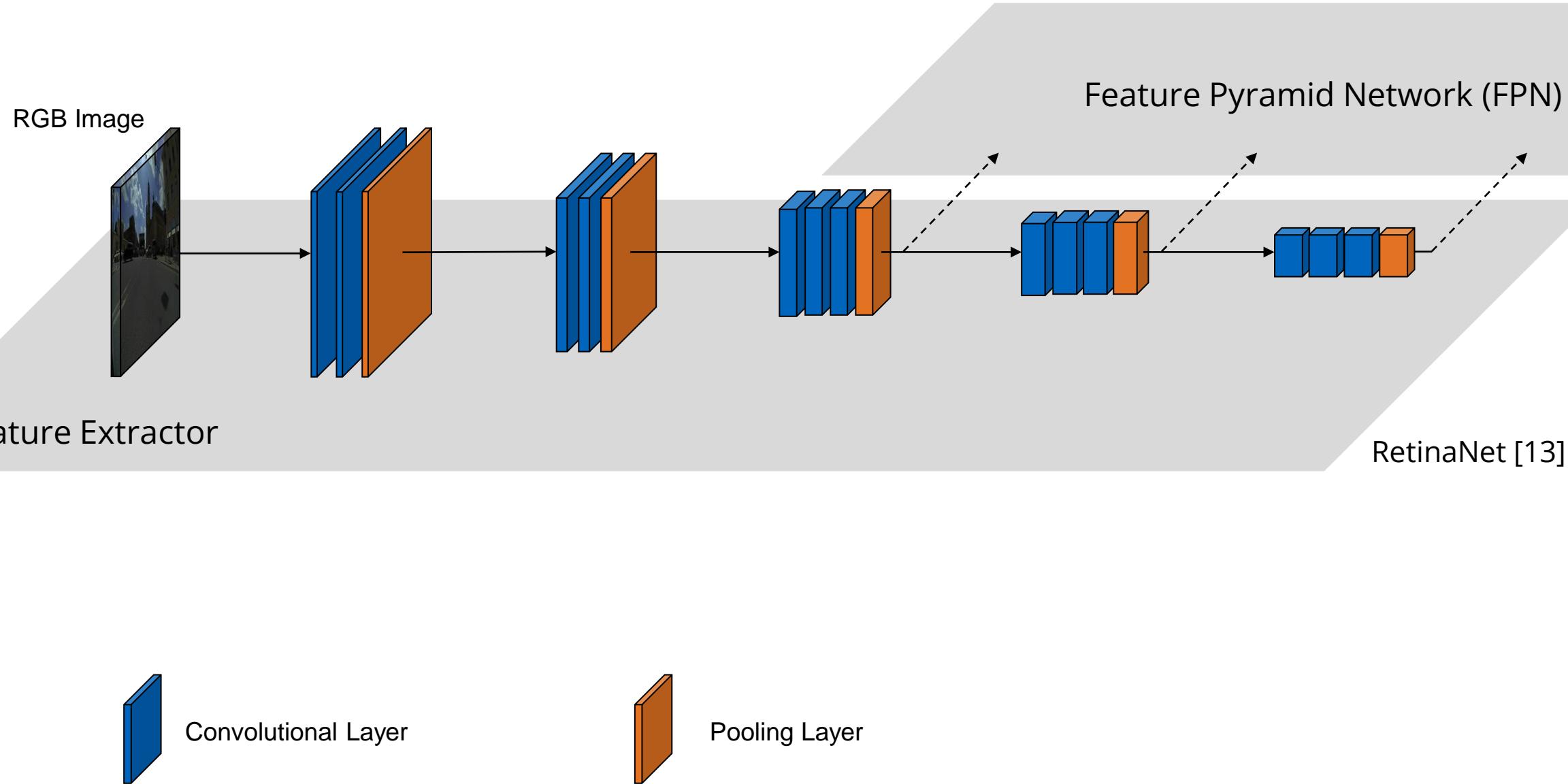
Obtainable Result



Strong result

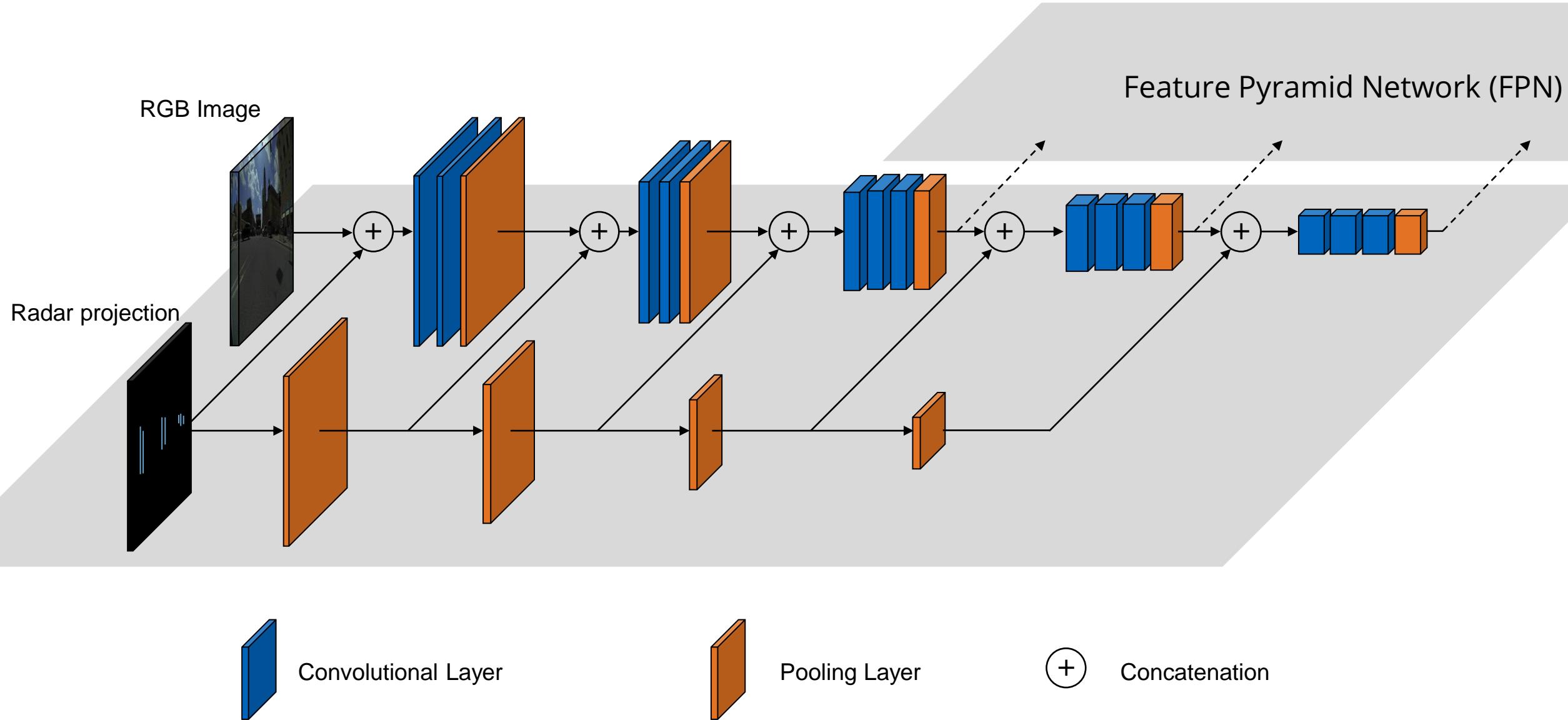
Datafusion in the Neural Network

driveblocks



Datafusion in the Neural Network

driveblocks



Results

Camera only



Sensor Fusion



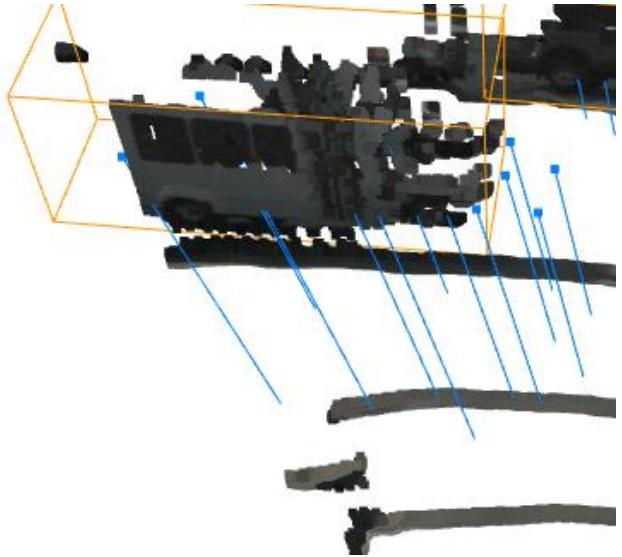
Results Adverse Conditions

Models	mAP	diff
Camera only, All	43.03%	-
Sensor Fusion + Filtering, All	55.99%	+12.96 AP
Camera only, Rain	39.44%	-
Sensor Fusion + Filtering, Rain	53.45%	+14.02 AP
Camera only, Night	45.46%	-
Sensor Fusion + Filtering, Night	66.32%	+20.86 AP

Impressions from developing a deep learning model

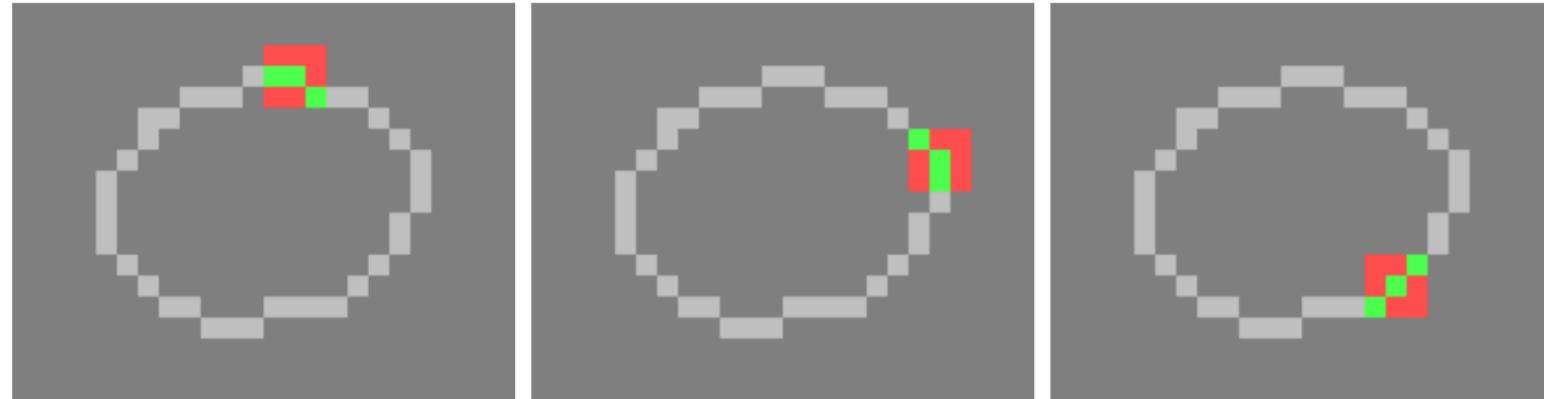
Convolutions in a sparse input space

driveblocks



3D camera, lidar, radar data

Sparse 3x3 Conv → No dilation



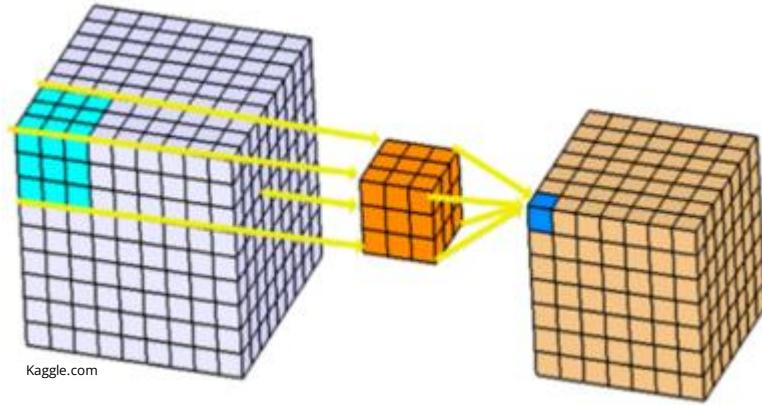
Standard 3x3 Conv → Dilation



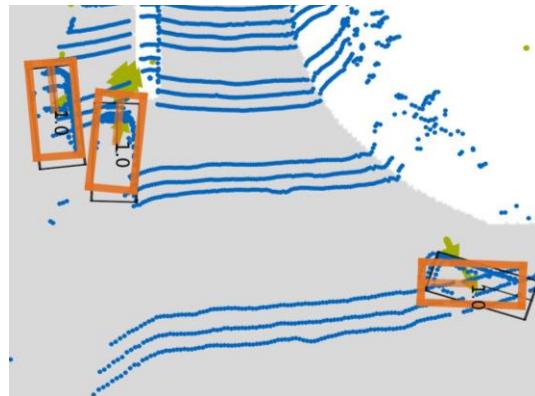
[Gra18]

Debug anchors and thresholds

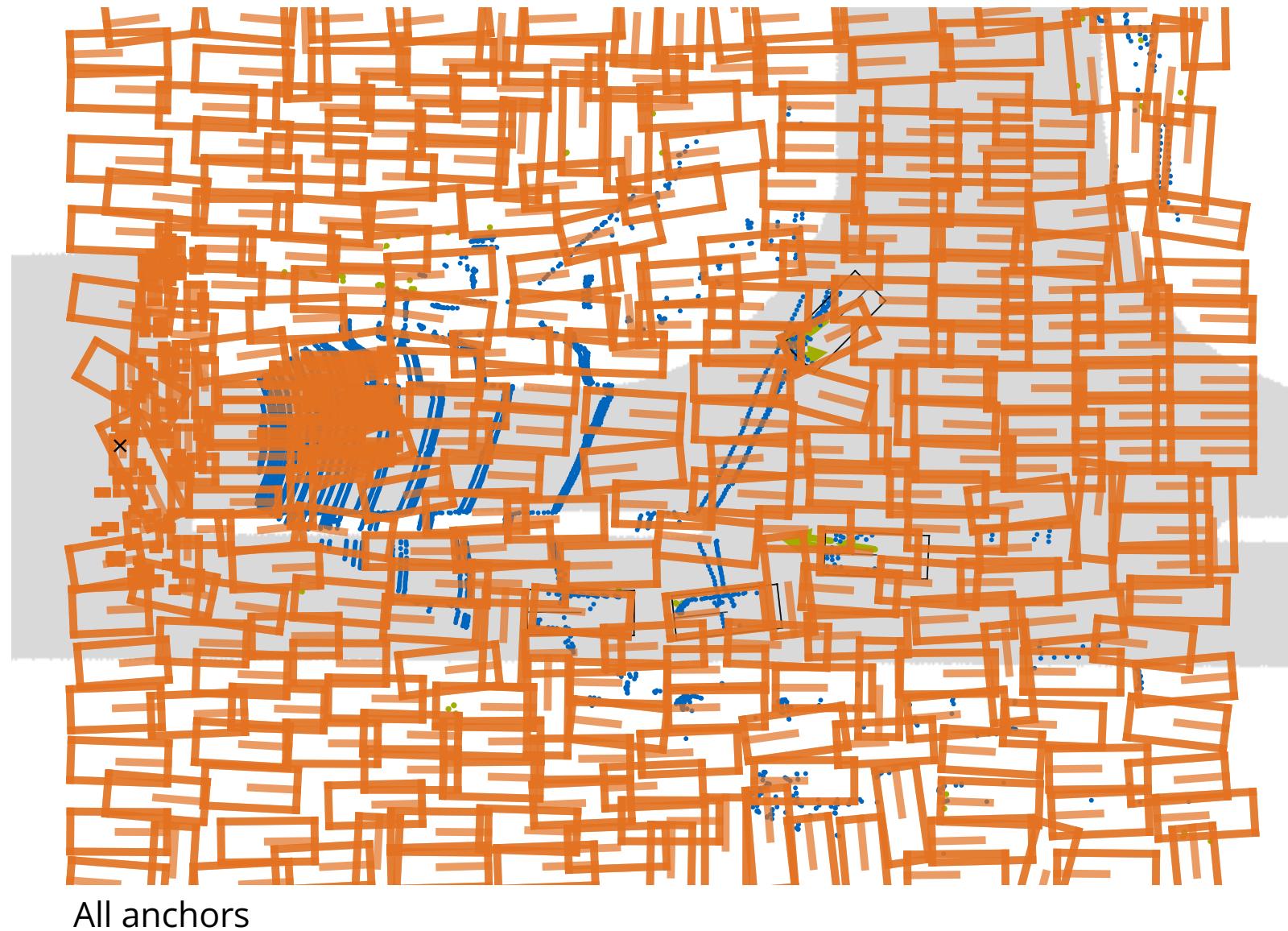
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Voxel grid to anchor feature map



Positive anchors for reference



All anchors

Debug anchors and thresholds

driveblocks



All anchors with confidence > 0.1

Debug anchors and thresholds

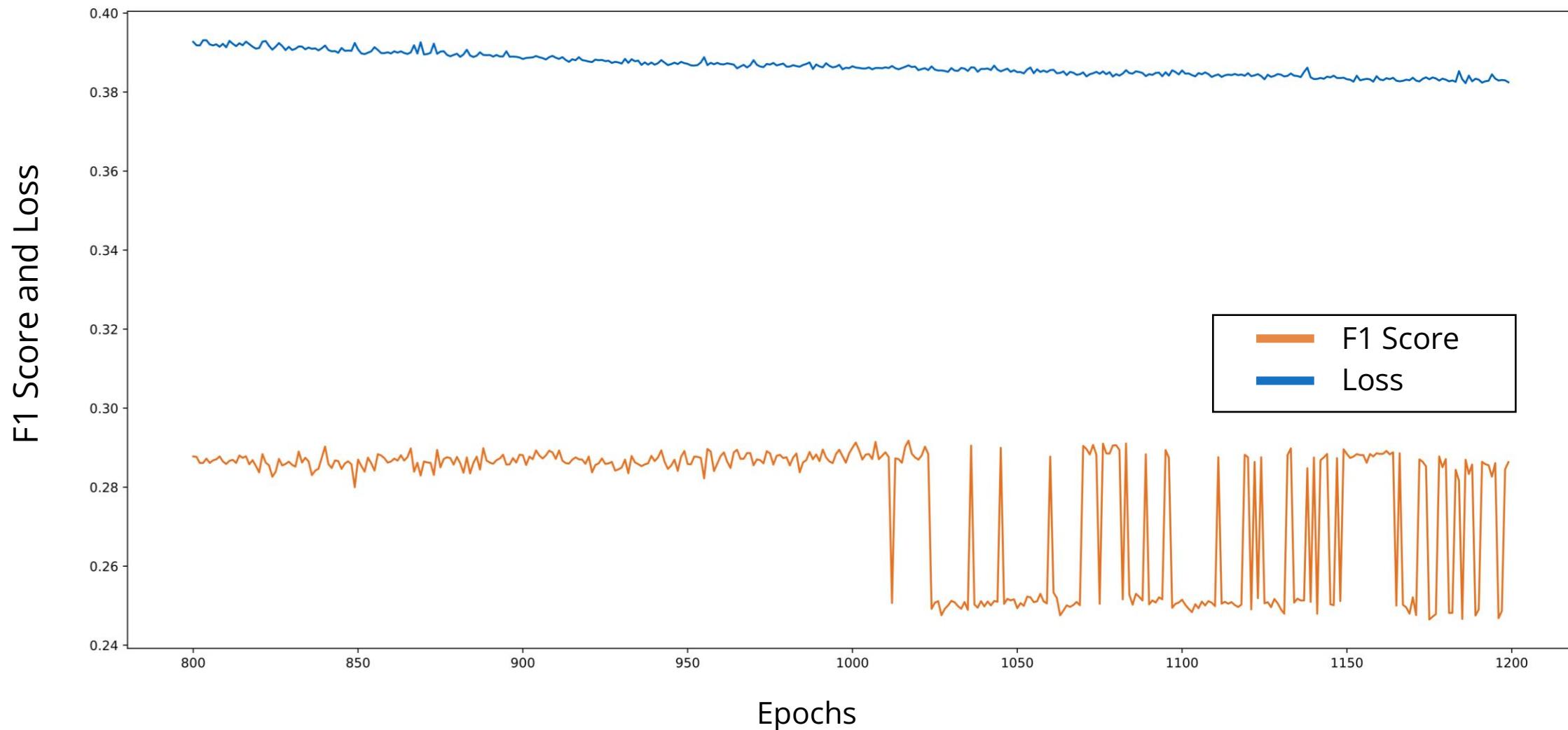
driveblocks



All anchors with confidence > 0.5

Disagreement of Loss and Metric

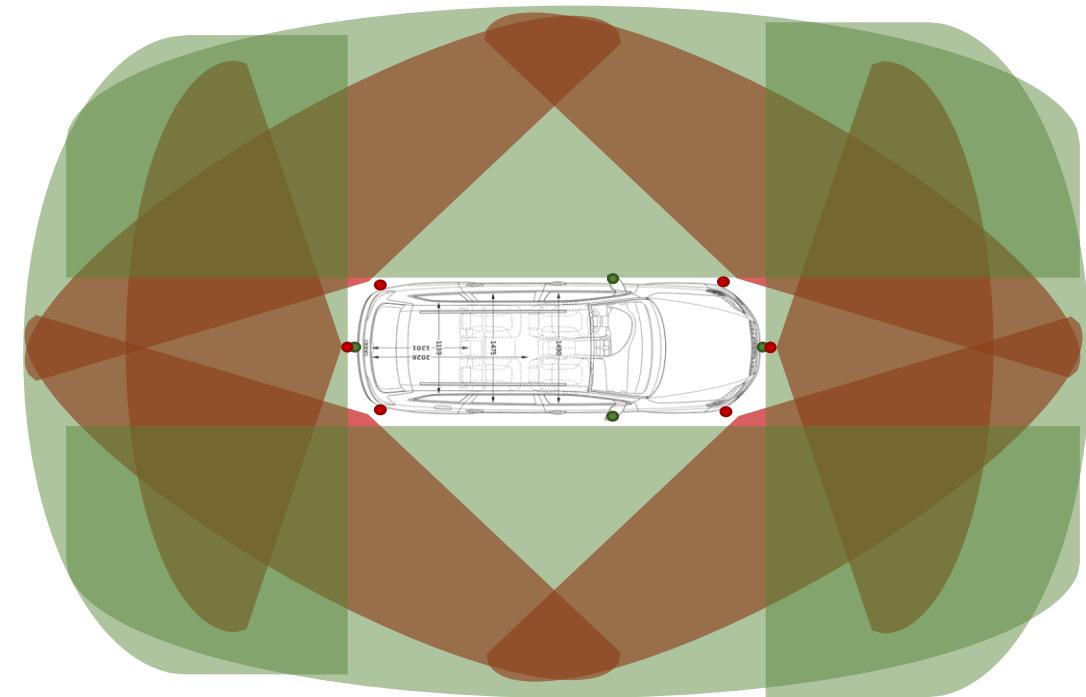
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What makes autonomous driving so hard in practice?

Sensor coverage

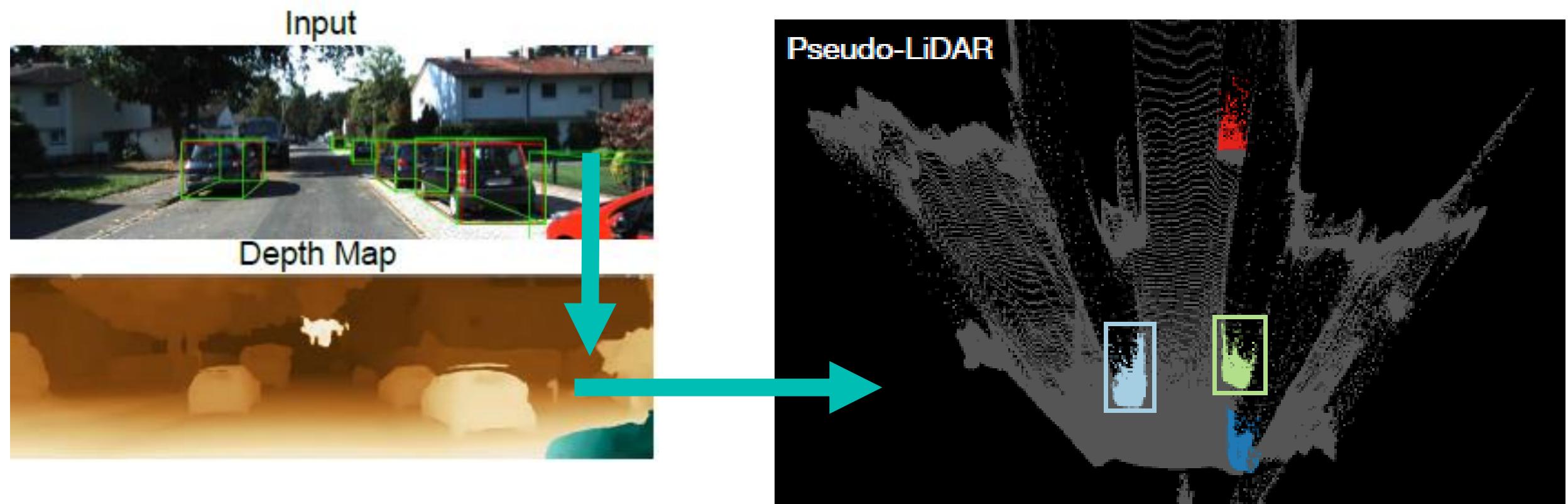
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globalDrive

3D detection is ill-posed

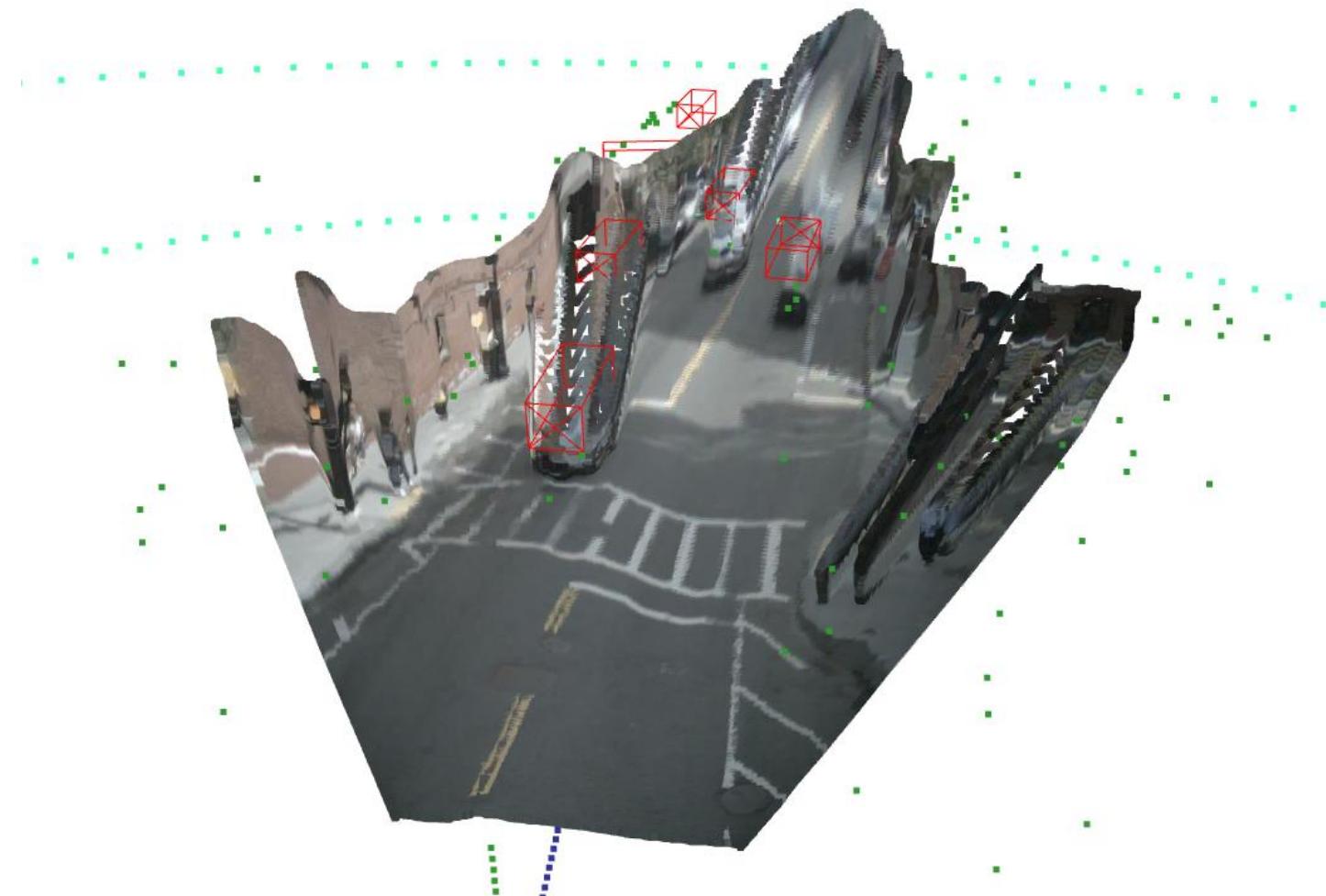
driveblocks



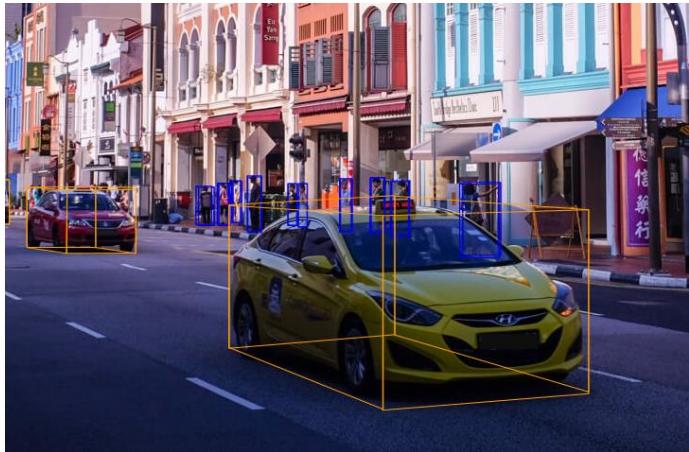
[3]

3D detection is ill-posed

driveblocks



Benchmark Datasets



The KITTI Vision
Benchmark Suite

Camera
Lidar

NUSCENES

Camera
Lidar
Radar

KITTI 3D [Gei13]
nuScenes [Cae19]

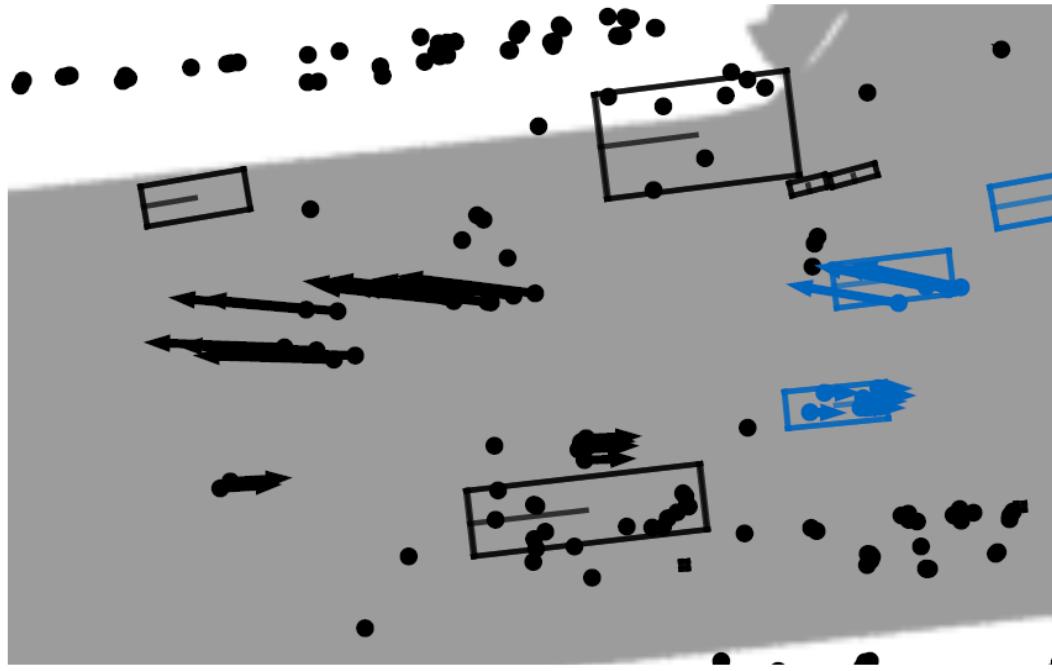
Real World



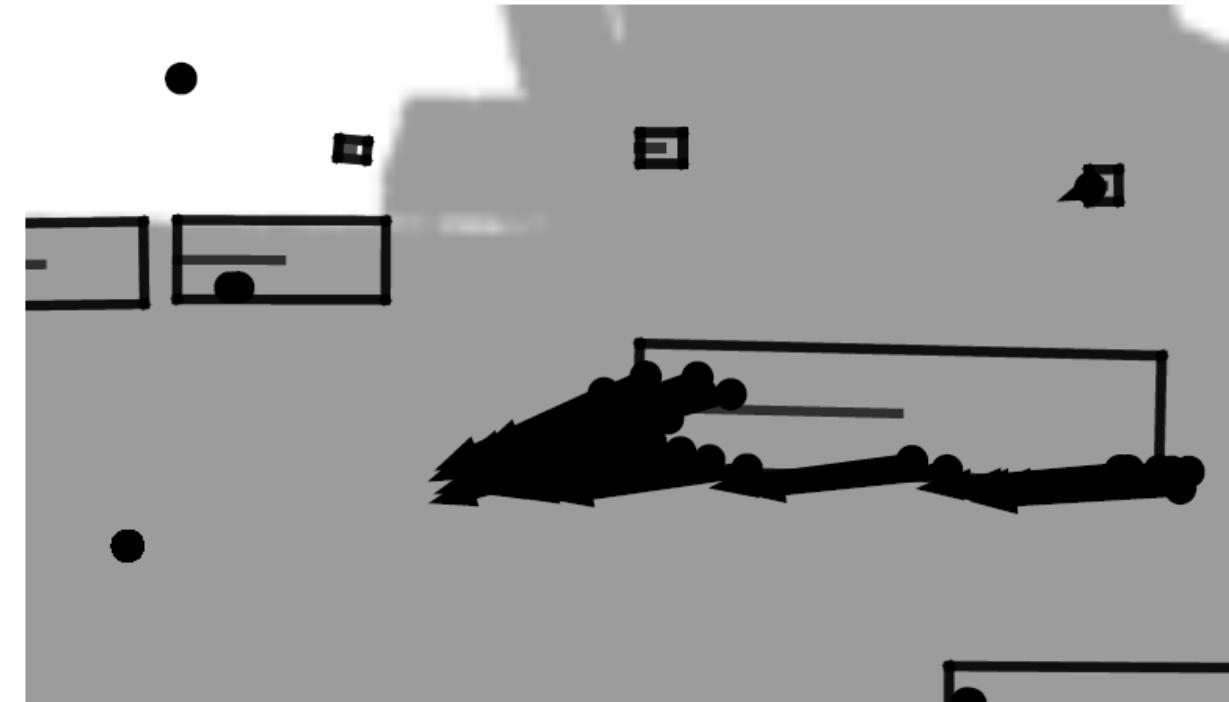
Wrong ground truth labels

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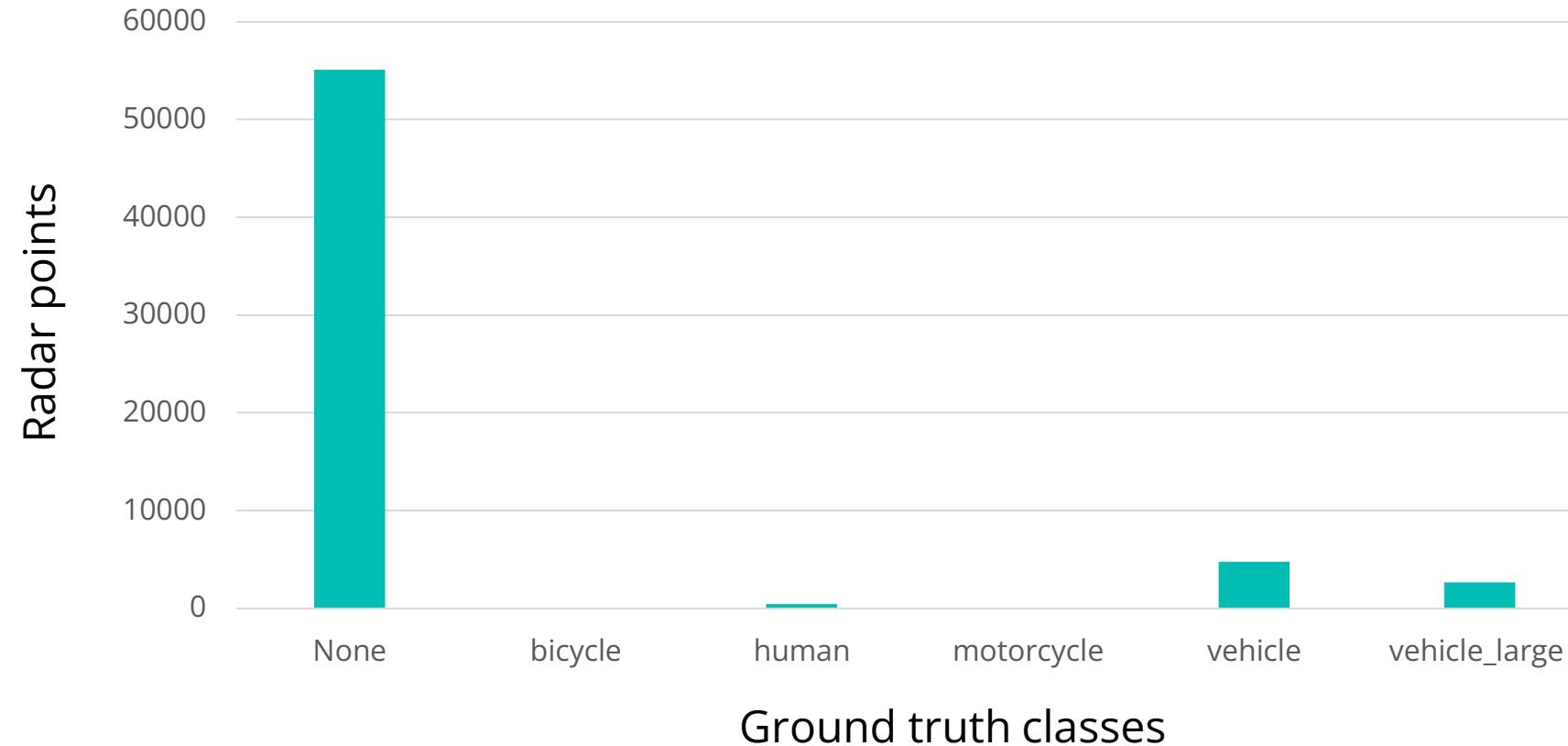
-  Moving vehicles
-  Static vehicles

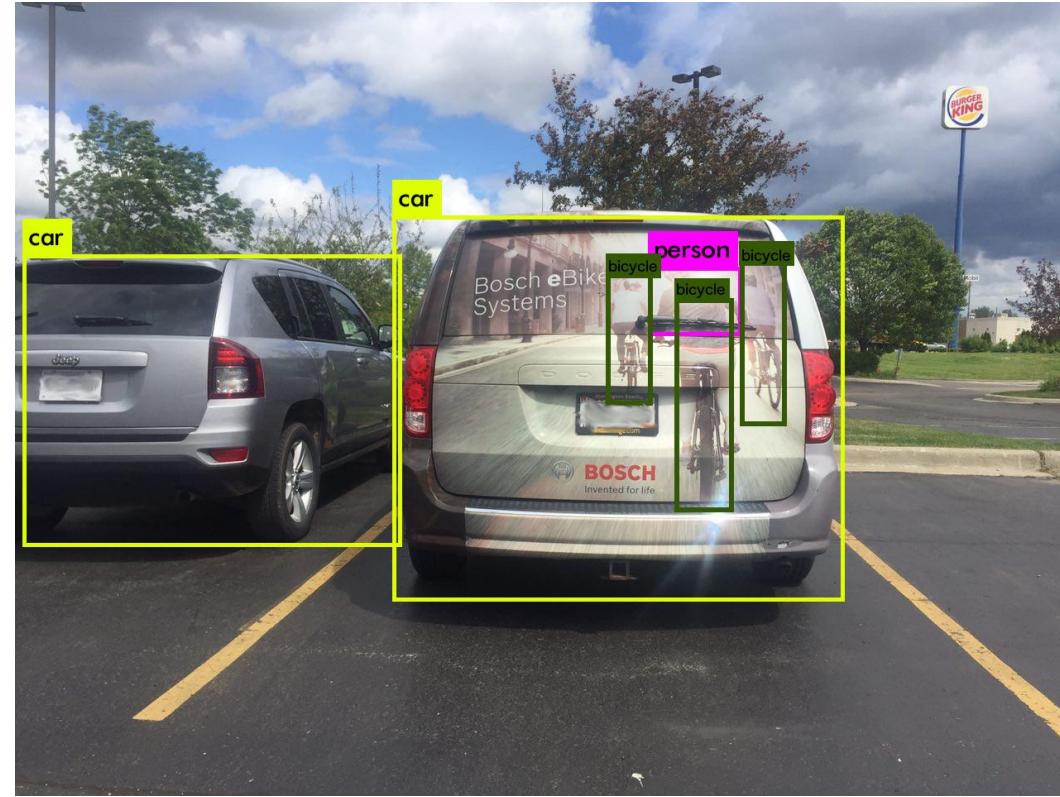


Missing labels of vehicles



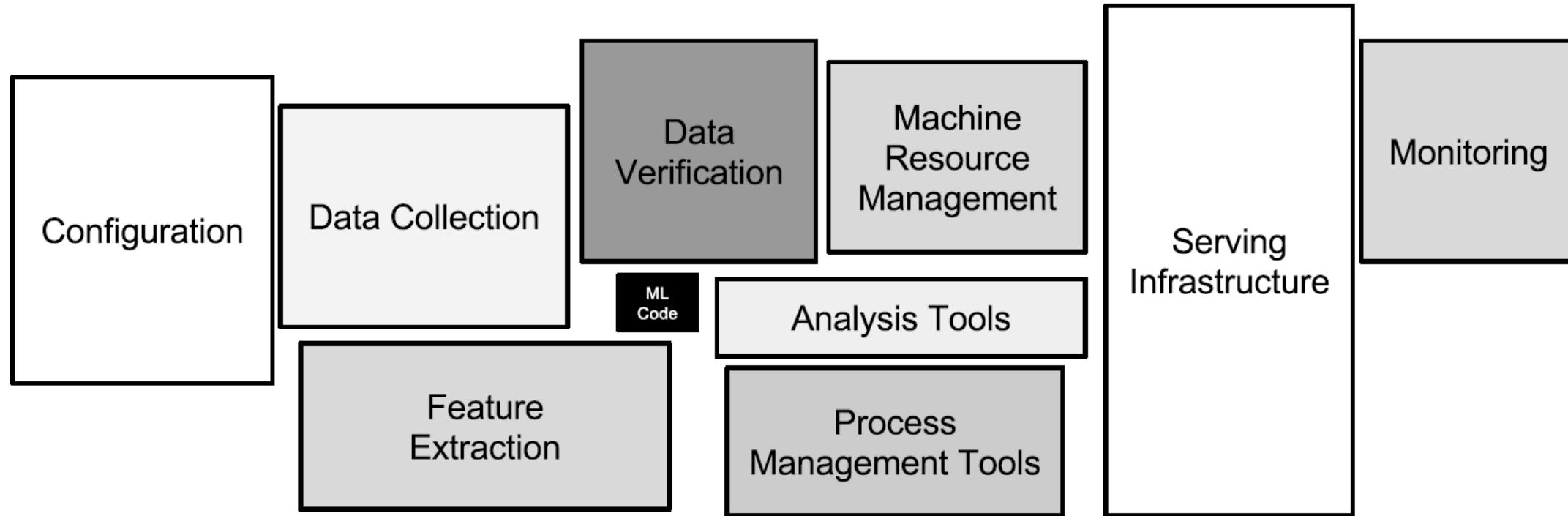
Wrongly classified vehicles







There is much more to AI than just building models



Hidden Technical Debt in Machine Learning Systems
<https://proceedings.neurips.cc/paper/2015/file/86df7dcfd896fcacf2674f757a2463eba-Paper.pdf>

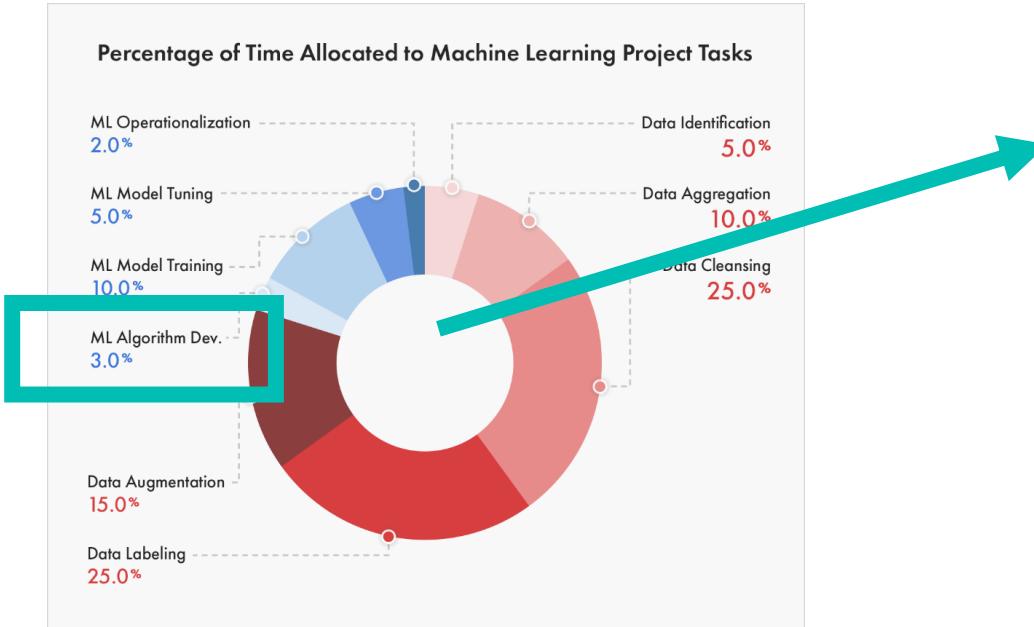
AI research has produced a lot of models

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Why do 87% of data science projects never make it into production?

<https://venturebeat.com/ai/why-do-87-of-data-science-projects-never-make-it-into-production/>

Research



<https://dzone.com/articles/an-introduction-to-data-labeling-in-artificial-int>

Production

	mlflow	TensorBoard	DVC	ClearML	Guild.ai	Kubeflow	Neptune.ai	Weights & Biases	Comet.ml	SageMaker Experiments	DAGsHub
Open source	Apache	Apache	Apache	SSPL	Apache	Apache	X	X	X	X	—
Platform & language agnostic	X	X	✓	X	X	X	X	X	X	X	✓
Experiment data access	Local / Cloud or API	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud
Easy to set up	✓	✓	✓	Open-source server is hard to set up	✓	X	✓	✓	✓	✓	✓
Custom visualizations	✓	✓	—	Difficult to customize	✓	X	✓	✓	✓	✓	X
Scalable for large number of experiments	✓	X	??	??	✓	✓	✓	✓	✓	✓	✓



Perfect for the internet – dangerous for the real world

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Expectation



Reality



salmon filet in river

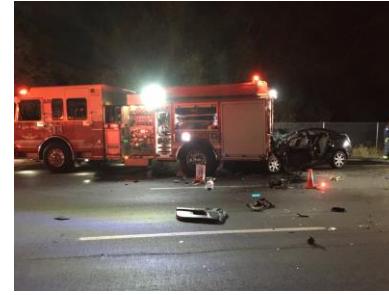


salmon swimming in river

Stable Diffusion
<https://arxiv.org/abs/2112.10752>
<https://replicate.com/stability-ai/stable-diffusion>

Tesla Crashes with Fire Trucks

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January 2018

May 2018

June 2018

August 2018

December 2019

[...] vehicles that have automated braking can't distinguish very well between a road sign and a stopped vehicle [...]

<https://www.bloomberg.com/news/articles/2019-09-06/spotting-a-fire-truck-ahead-is-easy-for-people-not-so-for-cars>

Volvo's semiautonomous system [...] "Pilot Assist will ignore the stationary vehicle and instead accelerate to the stored speed"

These systems are designed to ignore static obstacles because otherwise, they couldn't work at all.

<https://www.wired.com/story/tesla-autopilot-why-crash-radar/>

Autonomous driving software stack

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Imminent challenges for the AV industry

Are we trying to solve challenges that are too far out of reach?

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- Cities are tremendously complex.
- Self-driving is expensive. \$\$\$
- Are robo-taxis the right product for the customer now?

Again 3 Cruises Stuck

< Previous

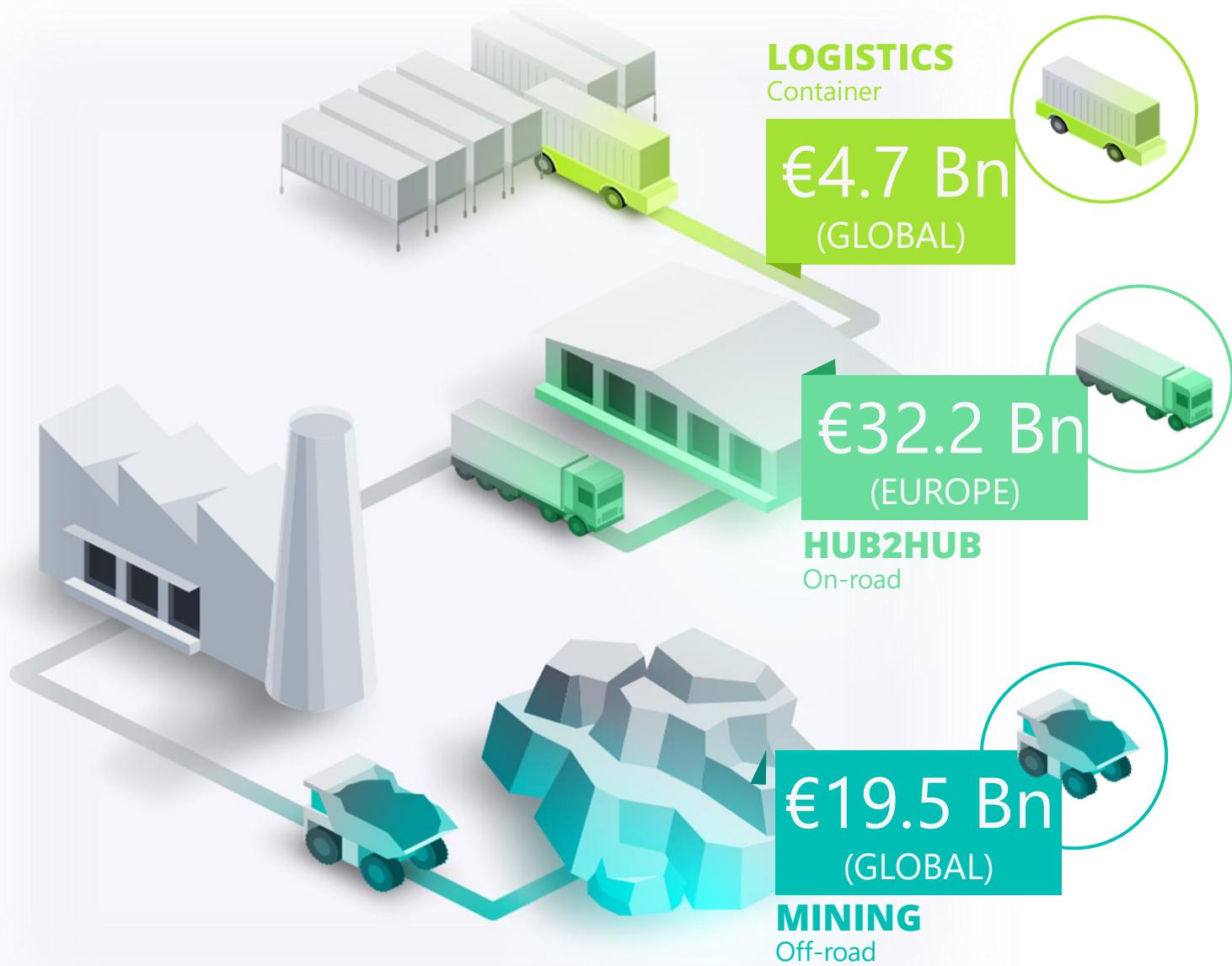
Next >

Mario Herger / September 23, 2022 / Autonomous Car, Cruise Automation, Robotaxi

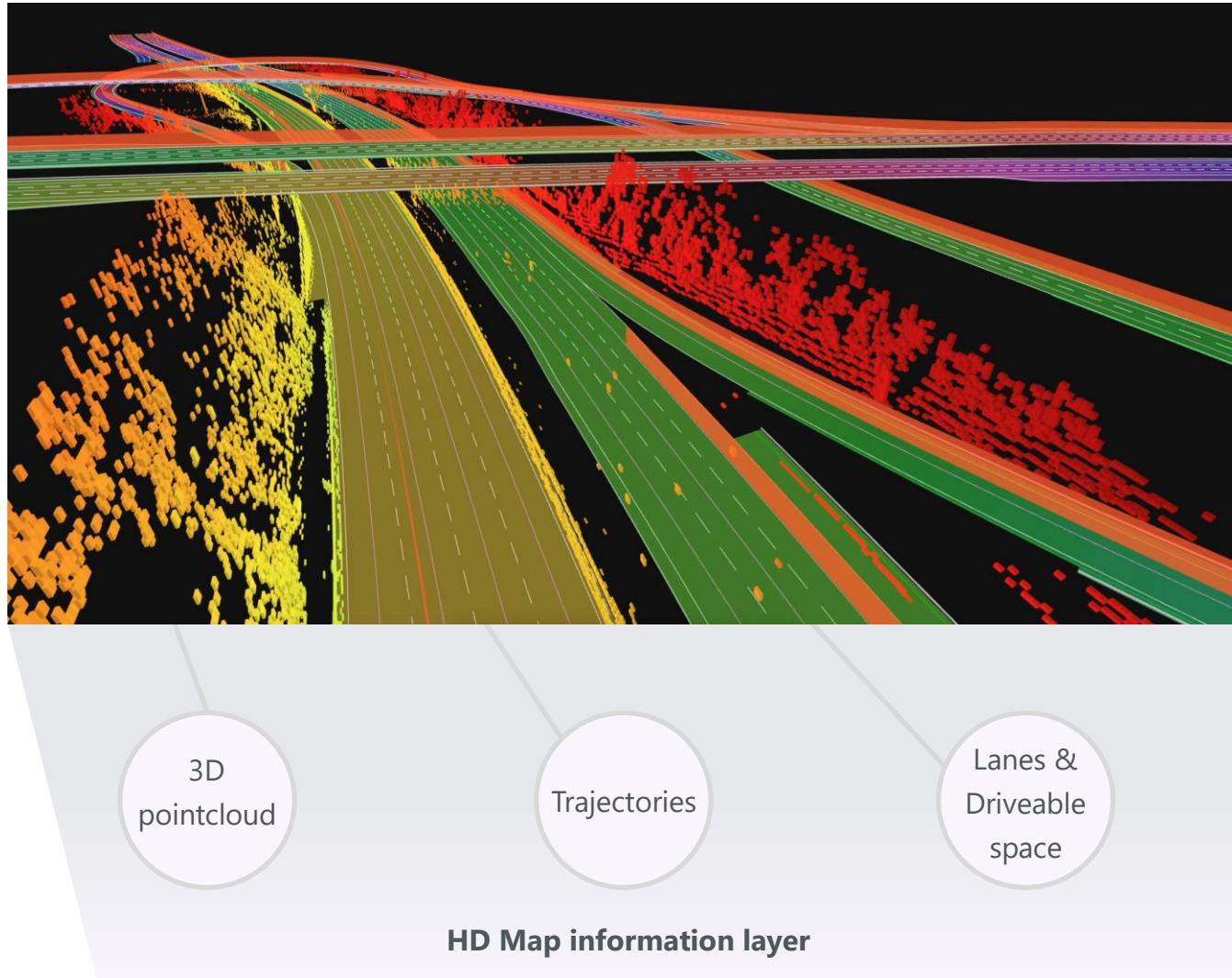


Constrained ODD with greater impact

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Major challenge in vehicle automation



Today, autonomous driving stacks use **High-Definition Maps** for various functions like localisation, lane detection, and trajectory planning.

Limitations:

- How to handle situations where the map is not up to date?
- Legislation requires vehicle to be safe without external dependencies such as map-updates
- Mapping and updating every route is costly and needs a lot of infrastructure



Safety



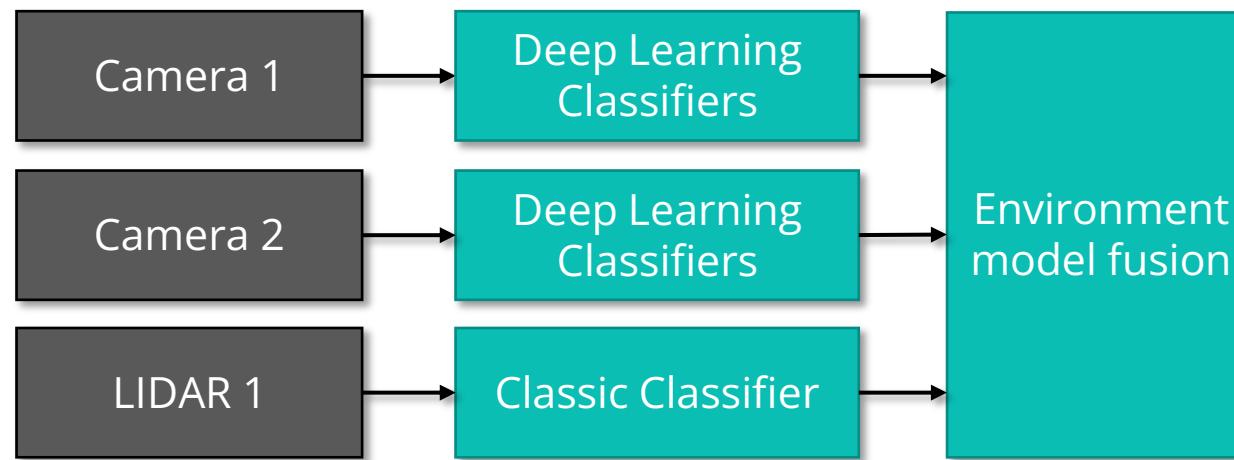
Scaling

Mapless environment model architecture

driveblocks

Multiple cameras to achieve true spatial vision capabilities.

Multi-pipeline architecture achieves fast reaction times through parallelization. Easy extension with additional pipelines and sensors.

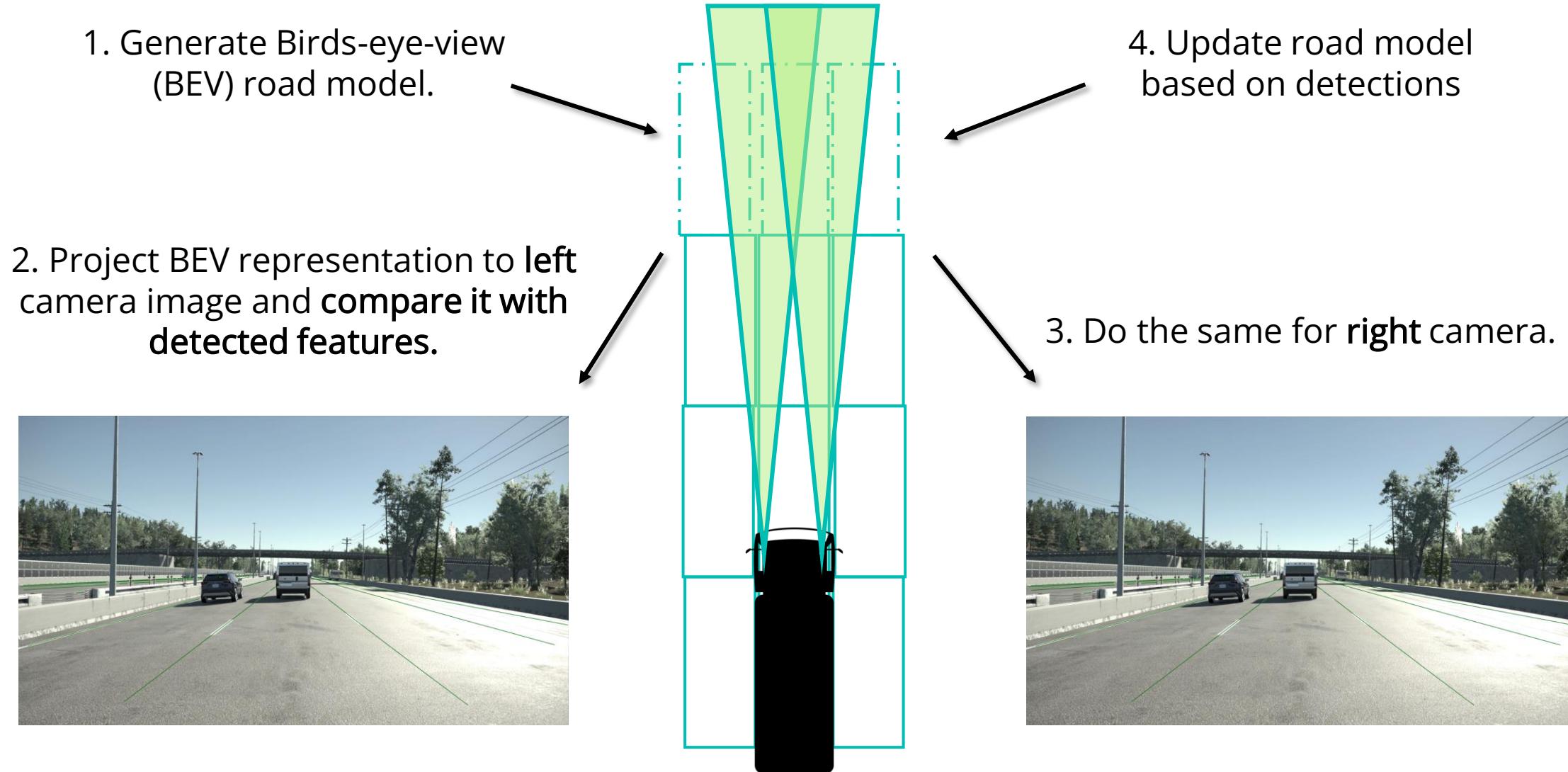


Combination of multiple sensor technologies for redundancy and safety.

Probabilistic sensor fusion to combine and verify inputs from all pipelines.

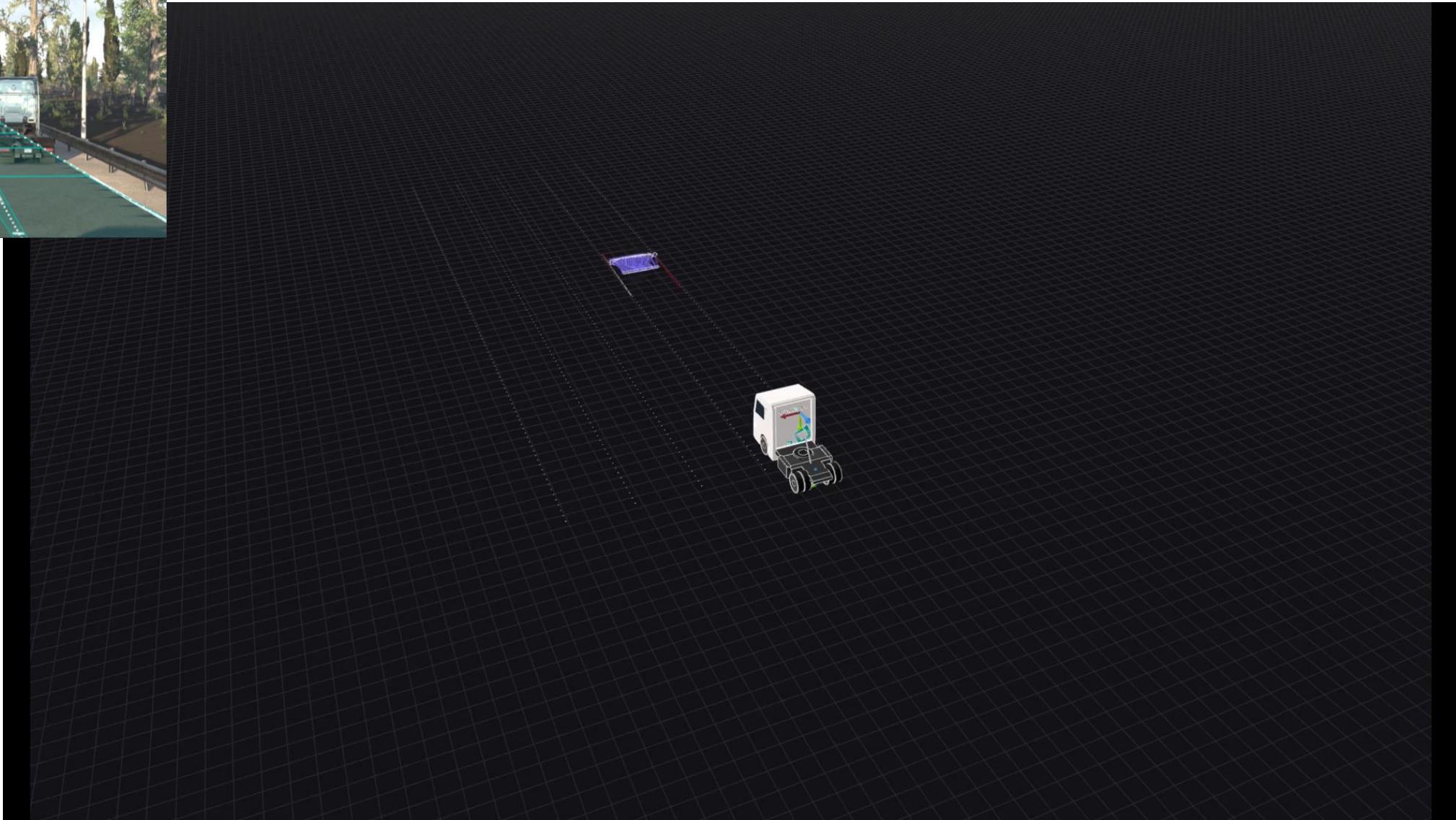
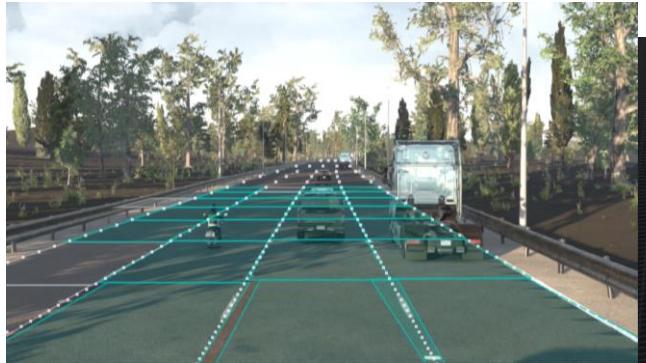
Multi-sensor approach to 3D transformation

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Data fusion to generate environment model

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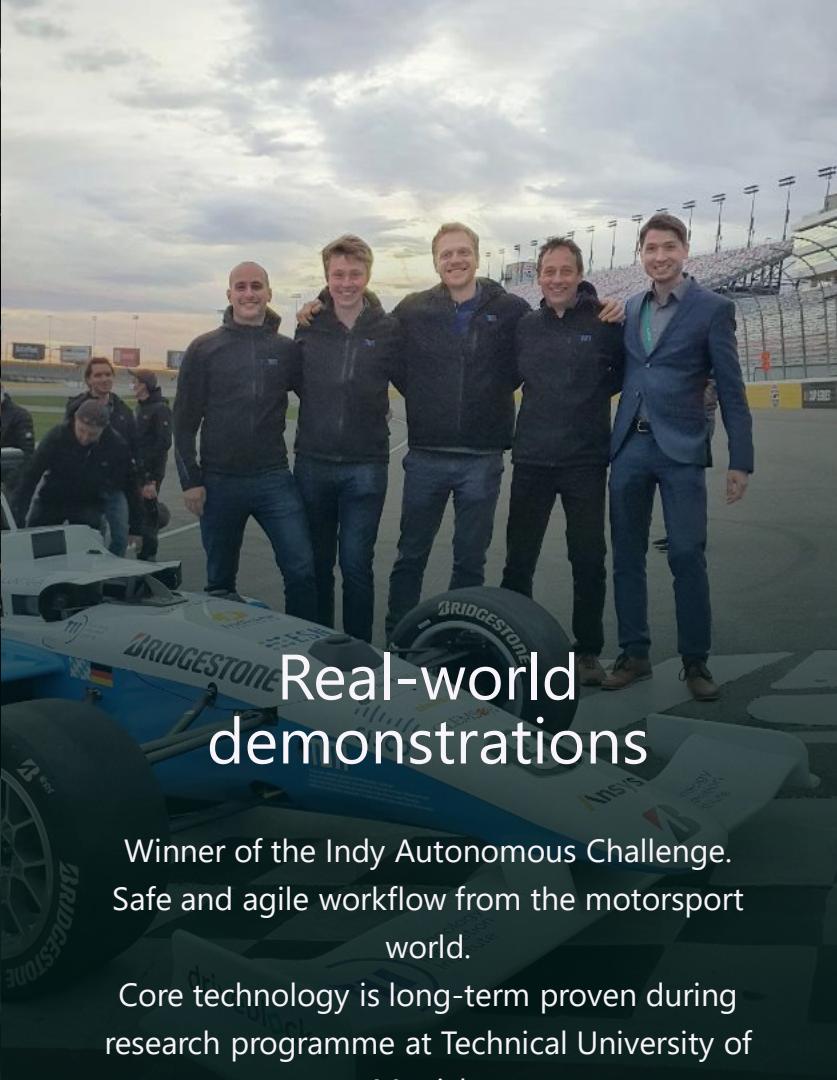
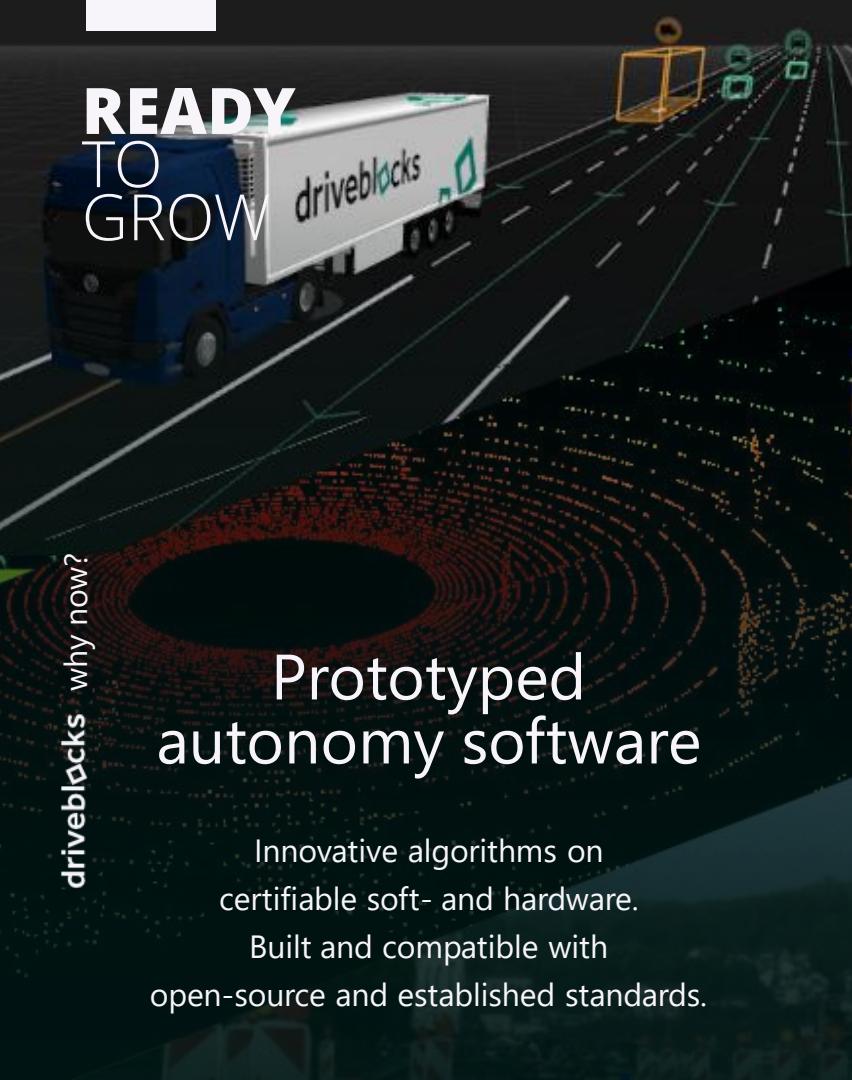
**READY
TO
GROW**

driveblocks why now?

Prototyped autonomy software

Innovative algorithms on certifiable soft- and hardware.

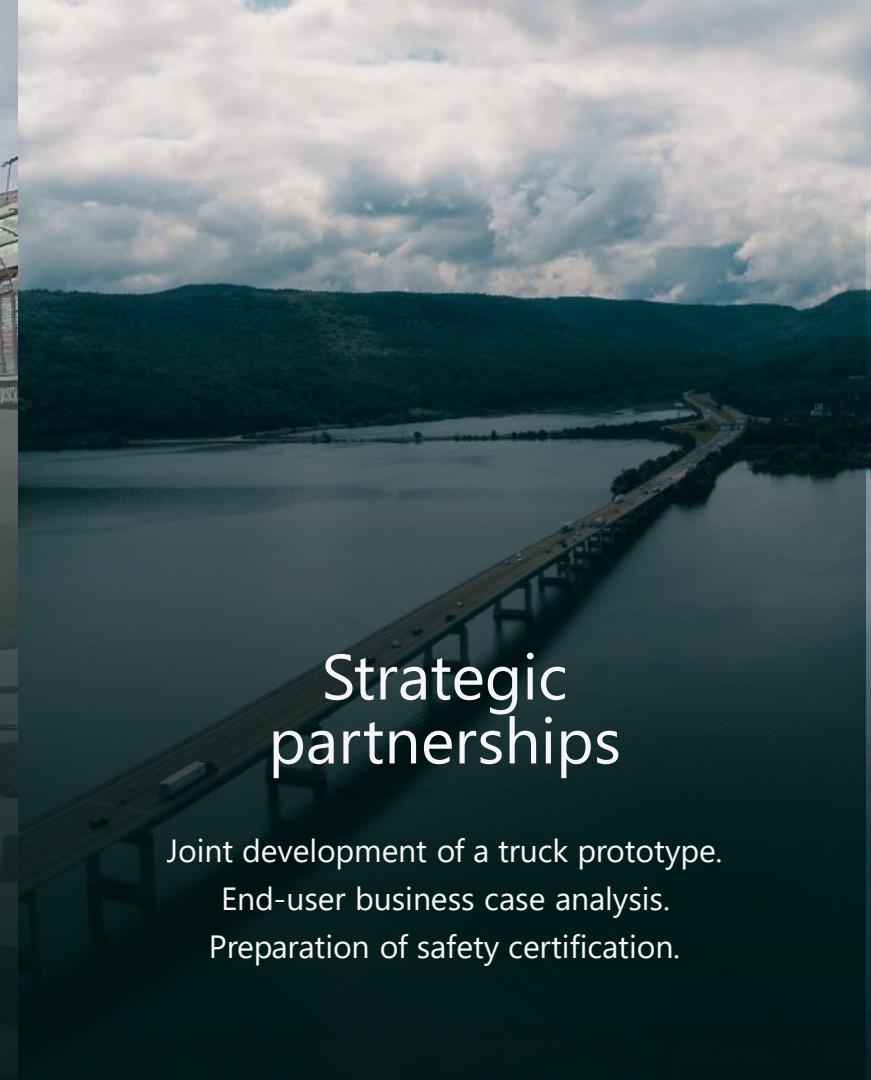
Built and compatible with open-source and established standards.



Real-world demonstrations

Winner of the Indy Autonomous Challenge.
Safe and agile workflow from the motorsport world.

Core technology is long-term proven during research programme at Technical University of Munich.



Strategic partnerships

Joint development of a truck prototype.
End-user business case analysis.
Preparation of safety certification.



DRIVEBLOCKS CORE TEAM

driveblocks



Dr. Stephan Matz
CEO



Alexander
Wischniewski
CTO



Dr. Tim Stahl
Environment Model
Lead



Thomas Herrmann
Motion Planning Lead



Dr. Felix Nobis
Perception Lead



Leonhard
Hermansdorfer
Simulation Lead

driveblocks team

Berkeley
UNIVERSITY OF CALIFORNIA

TUM

TU/e
EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

ROBORACE

INDY
AUTONOMOUS
CHALLENGE



Continental

BOSCH



CLAAS

DRIVEBLOCKS JOIN THE TEAM

Software Engineer – Working Student (Perception)
(m/f/d)

About Us

driveblocks changes the world of autonomous driving. Available market solutions are restrictively tailored to specific use-cases. Our team of world-class experts develops a scalable, modular platform that can easily be adapted to different applications. The platforms' structure is designed to be both, robust to environment conditions and safe by considering approval regulations from the start. It is built on open-standards and open-source technology to bridge the gap between technical demonstrations and safe series production vehicles.

Your Position

- Create state of the art solutions for making autonomous vehicles perceive the world around them. We offer different opportunities that can be tailored to your skills and interests.
- Areas of interest include: working on classical algorithms for computer vision, machine learning solutions and deep learning, hands-on sensor hardware technologies and interfaces, data engineering and MLops solutions – for object detection, free space detection and many more.
- Implement embedded algorithms which operate in real-time on an autonomous vehicle's control unit
- Work with state-of-the-art tools to develop efficient and safe software
- Design automatic tests which support the development of error-free algorithms
- Integrate your software package in our modular autonomous driving stack

Software Engineer – Working Student (Environment Model) (m/f/d)

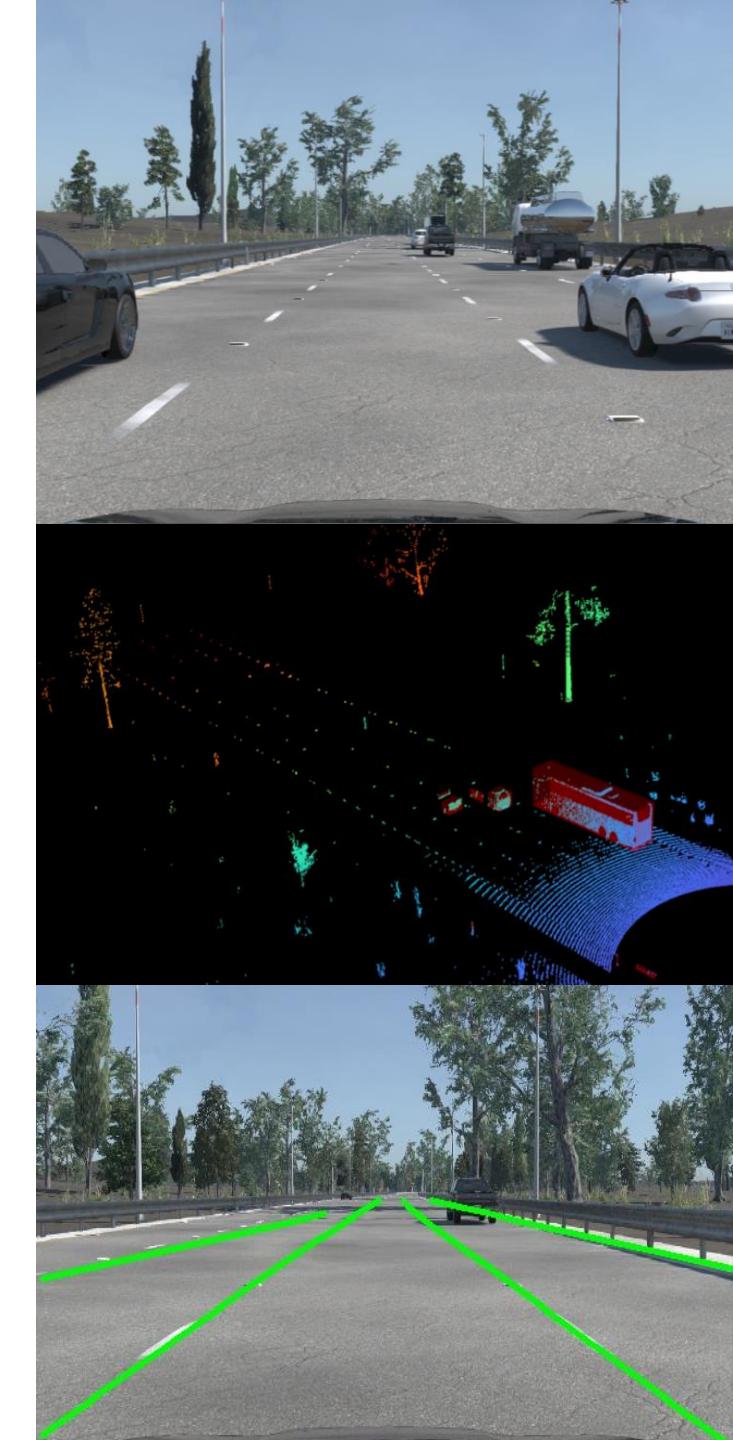
Requirements

- Bachelor's degree in computer science, informatics, engineering or related
- Basic knowledge about algorithms/workflows in the field of robotics and/or ML
- Experience with Linux, C/C++
- Ideally experience with git, ROS2, containerized development processes, automated software tests (CI/CD)
- 15+ hours availability

Working at driveblocks

- Learn and Grow – Working on the forefront of technology
- Open work environment – Challenge yourself and define your own focus
- Flexible working hours
- Competitive Compensation

<https://www.driveblocks.ai/jobs>



Key Takeaways

- AI is more than just models. Think about, data, hardware, system solution.
- Path to production for safety-critical systems is big challenge.
- AVs are complex products, AI models are only small building block.
- AI models are fairly mature in comparison to other needs towards AVs.

Contact

driveblocks



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LinkedIn