KI DELTA LEARNING
Scalable AI for Automated Driving

Final Event | March 09, 2023

KI Delta Learning - Project, Mission, Results

Dr.-Ing. Amin Hosseini

9:00 - 9:30	**Reception and Registration**
9:30 - 9:50	**Welcome and Agenda** Dr. Amin Hosseini, Mercedes-Benz, Coordinator KI Delta Learning Ernst Stöckl-Pukall, German Federal Ministry of Economic Affairs and Climate Action
9:50 - 10:15	**Keynote: Paths towards Open World Generalization** Prof. Dr. Thomas Brox, University of Freiburg
10:15 - 10:35	**KI Delta Learning – project, mission, results** Dr. Amin Hosseini, Mercedes-Benz
10:35 - 11:05	**Coffee Break**
11:05 - 11:30	**Data – The Basis for Delta Learning** Christian Witt, Valeo
11:30 - 12:30	**Transfer Learning** Introduction and Moderation: Dr. Jens Mehnert, Bosch
12:30 - 14:00	**Lunch Break and Poster Session**
14:00 – 15:00	**Didactics: Training Strategies for Delta Learning** Introduction and Moderation: Marius Bachhofer, ZF
15:00 – 15:30	**Automotive Suitability** Dr. Domenik Helms, DLR
15:30 – 16:00	**Coffee Break**
16:00 - 16:30	**Mercedes-Benz Operating System - Our Enabler for Scalable AI** *Magnus Östberg, Chief Software Officer (CSO), Mercedes-Benz*
16:30 - 17:15	**Panel: The Results of KI Delta Learning** Dr. Amin Hosseini (Moderator); Dr. Marius Cordts, Mercedes-Benz; Dr. Lothar Baum, Bosch; Dr. Georg Schneider, ZF; Prof. Dr. Hanno Gottschalk, Uni Wuppertal; Dr. Corina Apachite, Continental.
17:15 - 17:30	**Wrap-up and Farewell** Dr. Amin Hosseini, Coordinator KI Delta Learning

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Who are we?
Introduction to KI Familie

The KI Familie and its projects

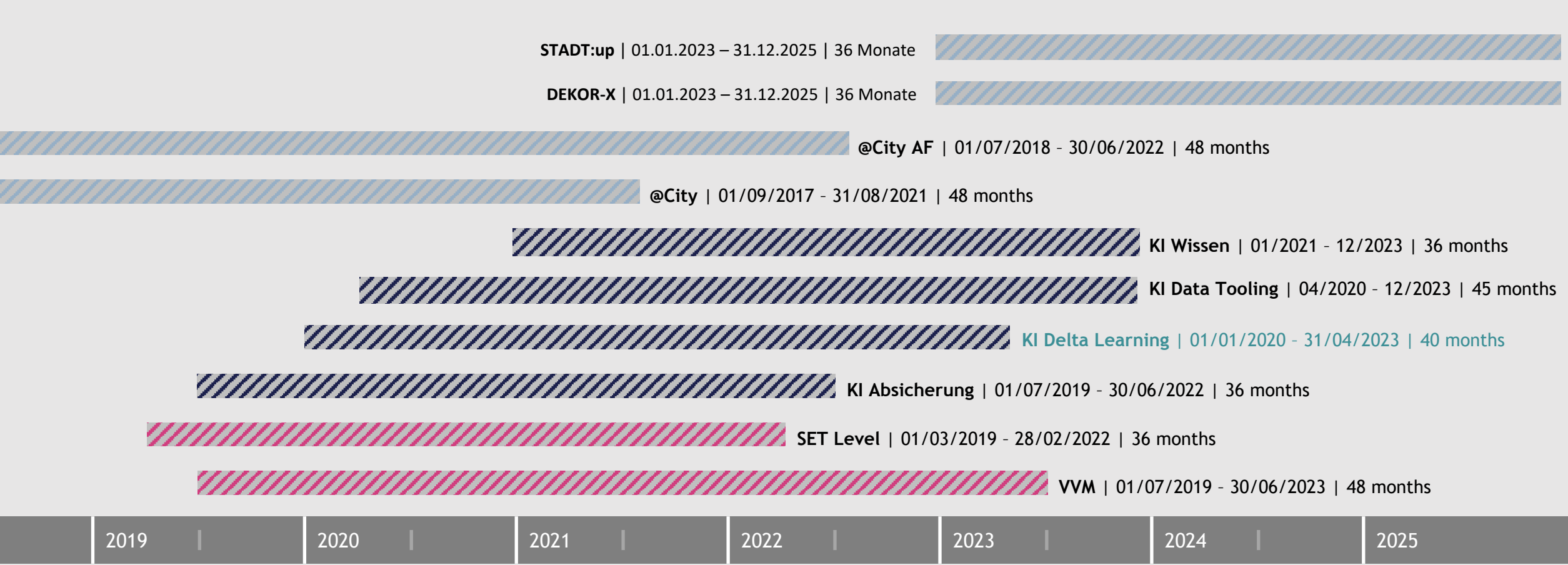**KI WISSEN** Development of methods for the integration of knowledge into machine learning

KI DELTA LEARNING
Development of methods and tools for the efficient expansion and transformation of existing AI modules in autonomous vehicles to meet the challenges of new domains or more complex scenarios

KI FAMILIE

KI ABSICHERUNG Methods and measures to safeguard AI-based perception functions for automated driving

KI DATA TOOLING Methods and tools for the generation and refinement of training, validation and safeguarding data for AI functions in autonomous vehicles

Overview of current projects of the VDA Leitinititative

STADT:up | 01.01.2023 – 31.12.2025 | 36 Monate

DEKOR-X | 01.01.2023 – 31.12.2025 | 36 Monate

@City AF | 01/07/2018 – 30/06/2022 | 48 months

@City | 01/09/2017 – 31/08/2021 | 48 months

KI Wissen | 01/2021 – 12/2023 | 36 months

KI Data Tooling | 04/2020 – 12/2023 | 45 months

KI Delta Learning | 01/01/2020 – 31/04/2023 | 40 months

KI Absicherung | 01/07/2019 – 30/06/2022 | 36 months

SET Level | 01/03/2019 – 28/02/2022 | 36 months

VVM | 01/07/2019 – 30/06/2023 | 48 months

| 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |

@City Familie   Pegasus Familie   KI Familie

KI Delta Learning: the project at a glance

| Project lead: | Mercedes-Benz AG | Project budget: | € 26.15 M | Project runtime: | 40 months | 17 partners |
| Project Co-lead: | ZF Friedrichshafen AG | Funding budget: | € 15.87 M | 01/01/2020 – 30/04/2023 | | |

OEMs

Mercedes-Benz · BMW GROUP · BMW · MINI

Tier-1

BOSCH · CARIAD A VOLKSWAGEN GROUP COMPANY · Porsche Engineering driving technologies · Valeo · ZF

Technology providers

MORE AUTOMOTIVE · InnoSenT

Research bodies

DLR · FZI

Universities

BERGISCHE UNIVERSITÄT WUPPERTAL · Hochschule Reutlingen Reutlingen University · Technische Universität München TUM · UNI FREIBURG · Universität Stuttgart · EBERHARD KARLS UNIVERSITÄT TÜBINGEN
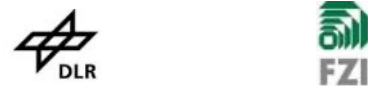
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What is KI Delta Learning about?

Scaling AI: Efficient inclusion of requirement changes into training
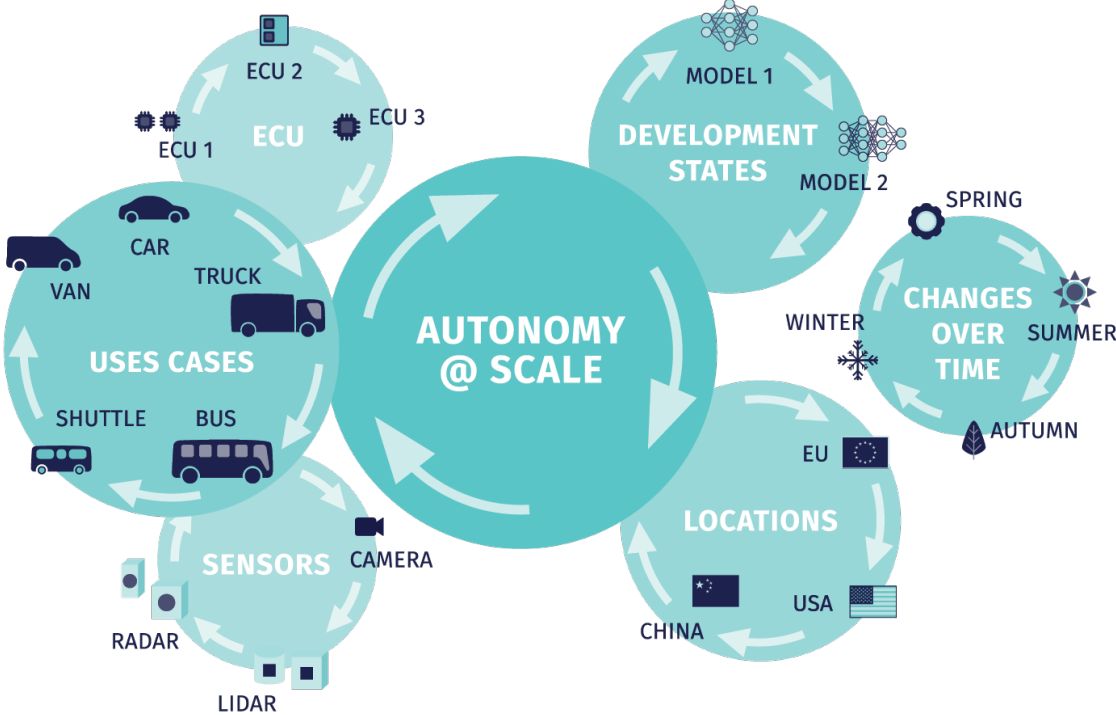
The dynamics of the automotive application field: An enormous amount of time and personnel is required for application-specific data acquisition as well as the retraining of algorithms. The goal is to reduce this learning dependency of data.
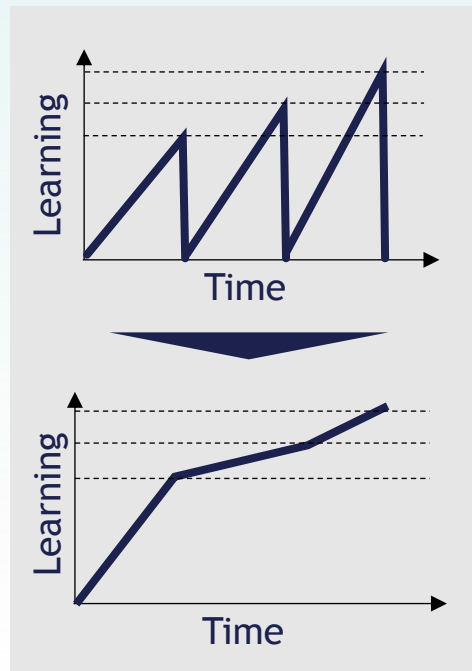
Goal: Scale AI solutions effectively and efficiently despite these dynamics and continuous changes

Autonomy @Scale

Expandability

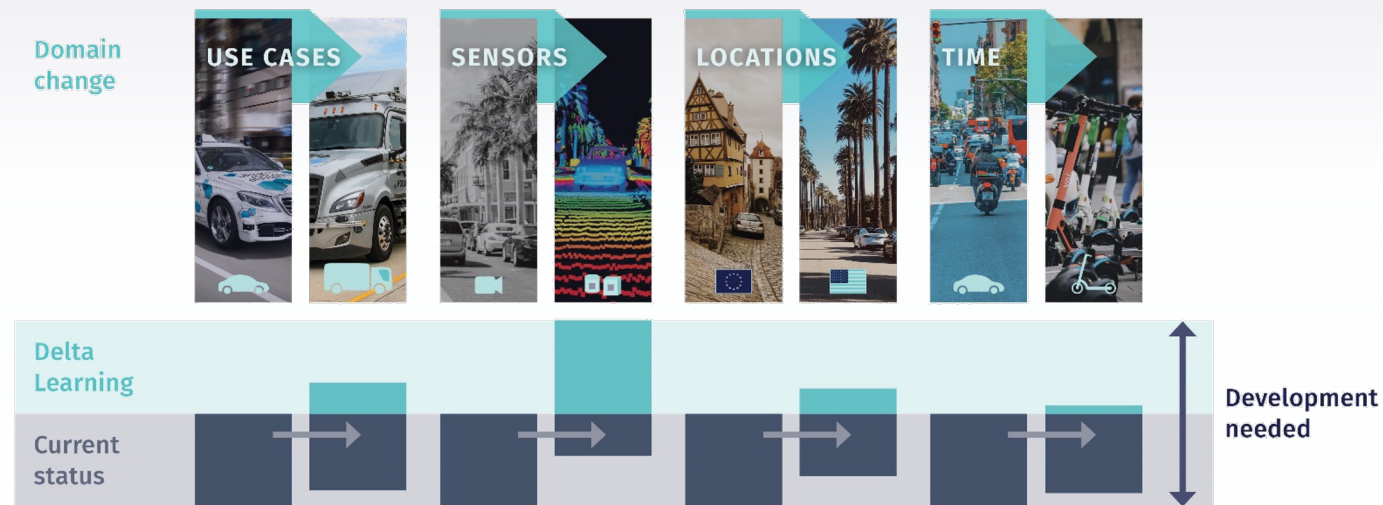Expanding AI systems through new features & functions

Flexibility

Learning to deal with changes & variants in new domains

Our approach for scaling effectively and efficiently:
Delta Learning

Methods and tools to efficiently extend and transform existing AI modules of autonomous vehicles to cope with new domains and complex scenarios in a continuously evolving traffic environment.

3

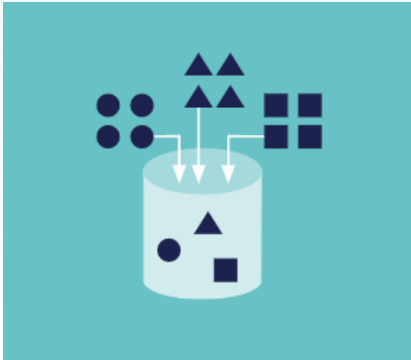## What was our approach in KI Delta Learning?
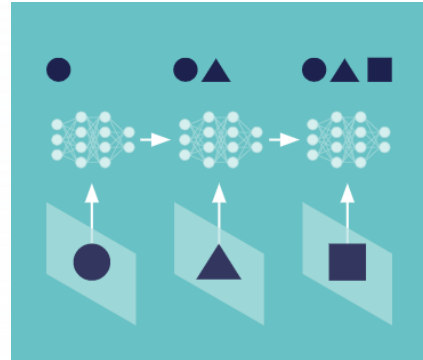
Our Approach in KI Delta Learning

Data Acquisition

Capturing Deltas: Different locations, weather conditions, synthetic data ...
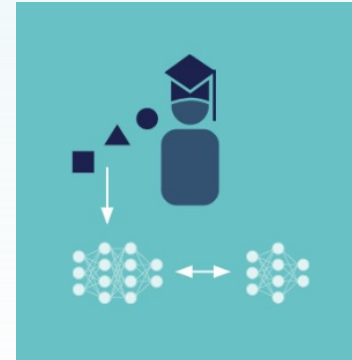

Transfer Learning

Transferring learned knowledge to new domains

Didactics

Controlling and guiding learning processes, developing learning strategies

Automotive Suitability

Considering the specific automotive requirements within the learning process

Data Acquisition – Sensor Delta

12 Cameras

❱ 1x **Reference Camera** 120° 8.9MP

❱ 1x **Wide FoV Camera** 130° 2.3MP

❱ 9x **Protocol Cameras** 90° 2.3MP

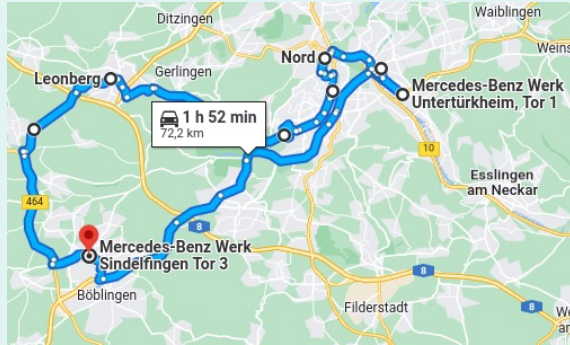❱ 1x **Serial Camera** (Bosch MPC3) 100° 2MP

5 LiDARs

❱ 1x **Reference LiDAR** 128 Layer

❱ 2x **Protocol LiDAR** 32 Layer

❱ 2x **Serial LiDAR** (Valeo Scala 16 Layer & Innoviz One)
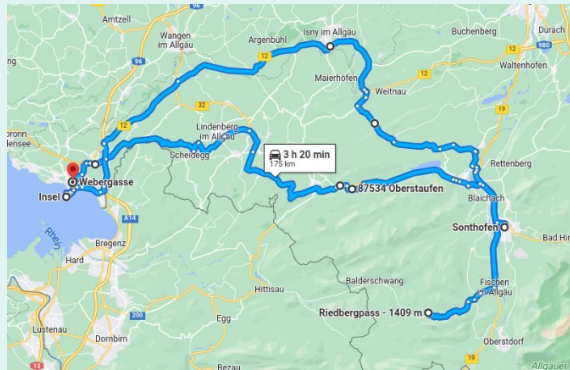
Other

❱ 2x **Radar** (InnoSenT 5G3)

❱ 1x **IMU**

Data Acquisition – Environment Delta

Local Drive (80km, 2:00h)
Sindelfingen → Stuttgart → Leonberg

Local Drive 2 (175km, 03:20h)
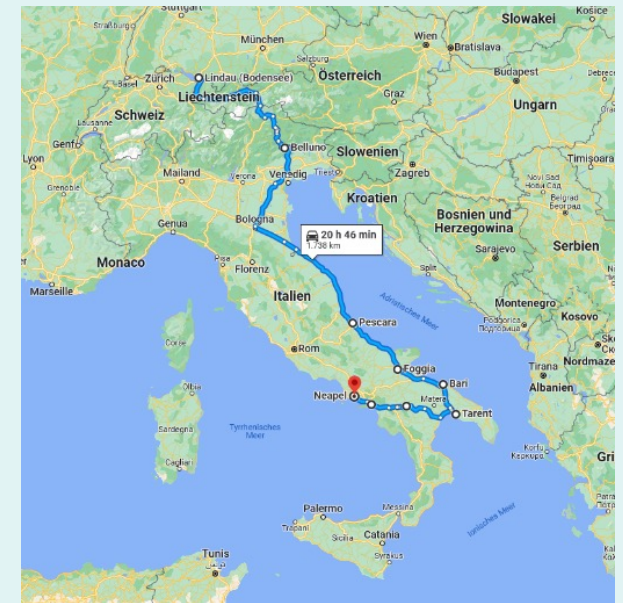*Lindau → Oberstaufen → Oberstaufen → Füssen → Riedbergpass → Isny*

Multi Day Drive (1500km, 16:30h)
Sindelfingen → Nürnberg → Leipzig → Berlin → Braunschweig → Würzburg
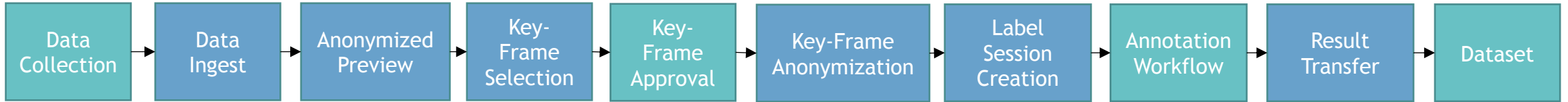
Day Drive (430km, 6:30h)
Sindelfingen → Lindau → Friedrichs- hafen → Jungnau → Reutlingen

Italy Drive (2880 km, 32:46h)
Sterzing → Belluno → Bologna → Pescara → Foggia → Bari → Tarent → Salerno - Neapel

Data Pipeline

Data Collection → Data Ingest → Anonymized Preview → Key-Frame Selection → Key-Frame Approval → Key-Frame Anonymization → Label Session Creation → Annotation Workflow → Result Transfer → Dataset

Automated Step
Manual Step

‹ KeyFrames: 1 of 82 ›

cam_windshield_reference

Manual Key Frame Setting

Value: True

From: 8 +

To: 8 +

↺ Reset   💾 Submit

key-frame
Street Surface
Type
Humidity
Sensor Effects
Cloudiness
Country
Season
Fast Tags

00:00:01 00:00:02 00:00:03 00:00:04 00:00:05

- TBD
- True
- Asphalt
- Dirt road
- Cobblestone
- Urban
- Rural
- Rain
- Dry
- Blindness
- None
- Partly Cloudy
- Dull
- Germany
- Autumn
- Special Street Surface
- Special Pedestrian
- Bridge
- Special Intersection
- Special Way
- Special Object
- Glare Sensor

Research Topics in Transfer Learning

Bosch

Bosch

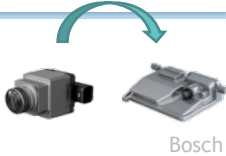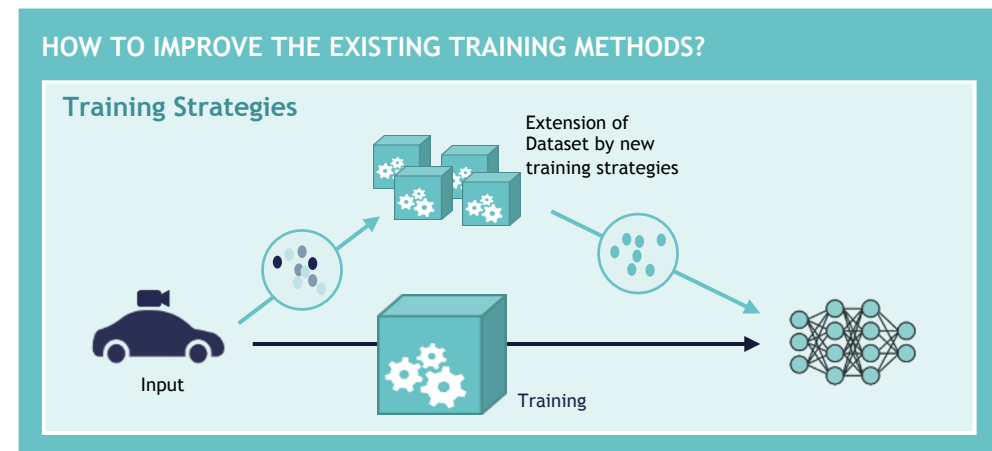| Continuous Learning | Synthetic data | Cross-Sensor-Adaption | Time and place adaptation | Environmental adaptation |

Bosch

Real world

Simulation

Bosch

Bosch

Research Topics in Didactics

HOW TO USE UNLABELED DATA?

Semi-supervised learning

Input — 10% Data — 90% Data — Training

Unsupervised learning

Input — Training

HOW TO TRANSFER ALREADY LEARNED KNOWLEDGE TO NEW MODELS?

Knowledge Transfer

Input — Training — Teacher — Knowledge Transfer — Student

WHAT DATA TO USE FOR TRAINING?

Active Learning

Input — Classification — Confident output / Output not confident — Active learning — Manual annotation

HOW TO IMPROVE THE EXISTING TRAINING METHODS?

Training Strategies

Input — Training — Extension of Dataset by new training strategies

Research Topics in Automotive Suitability

Robustness in open world

Challenge embedded systems

Project structure

KI DELTA LEARNING
Scalable AI for Automated Driving

TP1 — Valeo
Data acquisition

- **AP1.1** CMORE Automotive
  Integrated data management & processing
- **AP1.2** Valeo
  Real data recording
- **AP1.3** DLR
  Synthetic data generation
- **AP1.4** DLR
  Data labelling

TP2 — Bosch
Transfer learning

- **AP2.1** BMW
  Continuous learning
- **AP2.2** Valeo
  Use of synthetic data
- **AP2.3** Bosch
  Cross sensor adaptation
- **AP2.4** CARIAD
  Location and time domain
- **AP2.5** Mercedes-Benz
  Environment adaptation

TP3 — ZF
Didactics

- **AP3.1** Porsche Engineering
  Semi-supervised and unsupervised learning
- **AP3.2** BUW
  Training organisation
- **AP3.3** BMW
  Active learning
- **AP3.4** Mercedes-Benz
  Knowledge transfer

TP4 — DLR
Automotive suitability

- **AP4.1** Mercedes-Benz
  Robustness in the open world
- **AP4.2** DLR
  Challenges of embedded systems

TP5 — Mercedes-Benz
Evaluation

- **AP5.1** Mercedes-Benz
  Review and refinement
- **AP5.2** BMW
  Baseline and training of reference models
- **AP5.3** DLR
  Evaluation and demonstration

TP6 — Mercedes-Benz
Project organisation

- **AP6.1** Mercedes-Benz
  Management & coordination
- **AP6.2** Mercedes-Benz
  Exchange with other projects
- **AP6.3** Mercedes-Benz
  Dissemination of results

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Results

Publications

Nearly 100 scientific publications at well-respected conferences

If possible listed at https://www.ki-deltalearning.de/downloads with links to pdfs.

VERÖFFENTLI

Oberdiek, Philipp and Rottmann, Matthias and Fink, Gernot A.: Detection and Retrieval of Out-of-Distribution Objects in Semantic Segmentation. In: Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Workshops, 2020, pp. 328-329

Schwarz, Katja and Liao, Yiyi and Niemeyer, Michael and Geiger, Andreas: GRAF: Generative Radiance Fields for 3D-Aware Image Synthesis. In: Part of Advances in Neural Information Processing Systems 33 pre-proceedings (NeurIPS 2020). Presentation available here.

Schutera, Mark and Hussein, Mostafa and Abhau, Jochen and Mikut, Ralf and Reischl, Markus: Night-to-Day: Online Image-to-Image Translation for Object Detection Within Autonomous Driving by Night. In: IEEE Transactions on Intelligent Vehicles

Schutera, Mark and Hafner, Frank M. and Abhau, Jochen and Hagenmeyer, Veit and Mikut, Ralf and Reischl, Markus: Cuepervision: self-supervised learning for continuous domain adaptation without catastrophic forgetting. In: Vision and Image Computing as part of the special issue: Advances in Domain Adaptation for Computer Vision.

Monka, Sebastian and Halilaj, Lavdim and Rettinger, Achim: A Survey on Visual Transfer Learning using Knowledge Graphs. In: Semantic Web Journal (SWJ, IOS Press).

Monka, Sebastian and Halilaj, Lavdim and Schmid, Stefan and Rettinger, Achim: ConTraKG: Contrastive-based Transfer Learning for Visual Object Recognition using Knowledge Graphs. In: arXiv.

Saikia, Tonmoy, Schmid, Cordelia, Brox, Thomas: Improving robustness to distribution shift by combining frequency biased models. CVPR 2021, 19.-25.06.2021.

Kalb, Tobias, Roschani, Masoud, Ruf, Miriam, Beyerer, Jürgen: Continual Learning for Class- and Domain-Incremental Semantic Segmentation. In: 32nd IEEE Intelligent Vehicles Symposium, 10.07.2021.

Helms, Domenik, Amende, Karl, Bukhari, Saqib, de Graaff, Thies, Frickenstein Alexander, Hafner, Frank, Hirscher, Tobias, Mantowsky, Sven, Schneider, Georg, Vemparala, Manoj-Rohit: Optimizing Neural Networks for Embedded Hardware. In: IEEE International Conference on Synthesis, Modeling, Analysis and Simulation Methods and Applications to Circuit Design (SMACD), 19.07.2021.

Sauer, Axel and Geiger, Andreas: Counterfactual Generative Networks. In: ICLR 2021 (International Conference on Learning Representations).

Guerrero-Viu, Julia and Izquierdo, Sergio, Schröppel, Philipp and Brox, Thomas: Semi-Supervised Disparity Estimation with Deep Feature Reconstruction. In: Conference on Computer Vision and Pattern Recognition 2021 (CVPR).

Müller, Norman and Wong, Yu-Shiang and J. Mitra, Niloy and Dai, Angela and Niessner, Matthias: Seeing Behind Objects for 3D Multi-Object Tracking in RGB-D Sequences. In: Conference on Computer Vision and Pattern Recognition 2021 (CVPR).

Prakash, Aditу and Chitta, Kashyap and Geiger, Andreas: Multi-Modal Fusion Transformer for End-to-End Autonomous Driving. In: Conference on Computer Vision and Pattern Recognition 2021 (CVPR).

Hanselmann, Niklas and Schneider, Nick and Ortelt, Benedikt and Geiger, Andreas: Learning Cascaded Detection Tasks with Weakly-supervised Domain Adaptation. In: IEEE Intelligent Vehicles Symposium.

Triess, Larissa T. and Dreissig, Mariella and Rist, Christoph Bernd and Zöllner, J. Marius: A Survey on Deep Domain Adaptation for LiDAR Perception. In: IEEE Intelligent Vehicles Symposium.

Niemeijer, Joshua and Schäfer, Jörg P.: Combining Semantic Self-Supervision and Self-Training for Domain Adaptation in Semantic Segmentation. In: 2021 IEEE Intelligent Vehicles Symposium (IV).

Hornauer, Julia and Nalpantidis, Lazaros and Belagiannis, Vasileios: Visual Domain Adaptation for Monocular Depth Estimation on Resource-Constrained Hardware. In: ICCV2021, ERCVAD Workshop.

Mantowsky, Sven and Heuer, Falk, and Bukhari, Saqib and Keckeisen, Michael and Schneider, Georg: ProAI: An Efficient Embedded AI Hardware for Automotive Applications - a Benchmark Study. In: ICCV2021, ERCVAD Workshop.

Heuer, Falk and Mantowsky, Sven and Bukhari, Syed Saqib and Schneider, Georg: MultiTask-CenterNet (MCN): Efficient and Diverse Multitask Learning Using an Anchor Free Approach. In: ICCV2021, ERCVAD Workshop.

Poucin, Florentin and Kraus, Andrea and Simon, Martin: Boosting Instance Segmentation With Synthetic Data: A Study To Overcome the Limits of Real World Data Sets. In: ICCV2021, ERCVAD Workshop.

Lyssenko, Maria and Gladisch, Christoph and Heinzemann, Christian and Woehrle, Matthias and Triebel, Rudolph: Instance Segmentation in CARLA: Methodology and Analysis for Pedestrian-Oriented Synthetic Data Generation in Crowded Scenes. In: ICCV2021, ERCVAD Workshop.

Chitta, Kashyap and Prakash, Aditya and Geiger, Andreas: NEAT: Neural Attention Fields for End-to-End Autonomous Driving. In: ICCV 2021.

Hubschneider, Christian, Birkenbach, Marius , Zöllner, J. Marius: Unsupervised Domain Adaptation via Shared Content Representation for Semantic Segmentation. In: 24th IEEE International Conference on Intelligent Transportation - ITSC2021, Indianapolis, 19.-22.09.2021.

Termöhlen, Jan-Aike, Klingner, Marvin, Brettin, Leon J., Schmidt, Nico M., Fingscheidt, Tim: Continual Unsupervised Domain Adaptation for Semantic Segmentation by Online Frequency Domain Style Transfer. In: 24th IEEE International Conference on Intelligent Transportation - ITSC2021, Indianapolis, 19.-22.09.2021.

Triess, Larissa T. and Peter, David and Baur, Stefan A. and Zöllner, Marius J.: Quantifying point cloud realism through adversarially learned latent space representations. In: 2021 German Conference on Pattern Recognition (GCPR).

Bouazizi, Arij and Wiederer, Julian and Kressel, Ulrich and Belagiannis, Vasileios: Self-Supervised 3D Human Pose Estimation with Multiple-View Geometry. In: IEEE - International Conference on Automatic Face & Gesture Recognition.

Makansi, Osama, Çiçek, Özgün, Marrakchi, Yassine, Brox, Thomas: On Exposing the Challenging Long Tail in Future Prediction of Traffic Actors. In: International Conference on Computer Vision (ICCV), 11.10.2021.

Wiederer, Julian, Bouazizi, Arij, Troina, Marco, Kressel, Ulrich, Belagiannis, Vasileios: Anomaly Detection in Multi-Agent Trajectories for Automated Driving. In: Conference on Robot Learning (CoRL), 08.11.2021.

Sauer, Axel, Chitta, Kashyap, Müller, Jens, Geiger, Andreas: Projected GANs Converge Faster. In: Neural Information Processing Systems, 06.12.2021.

Workshop Series Autonomy@Scale launched at IEEE IV

- Half-day workshops within well-respected frame
- Invited talks and paper presentation focussing delta-learning topics

Autonomy@Scale
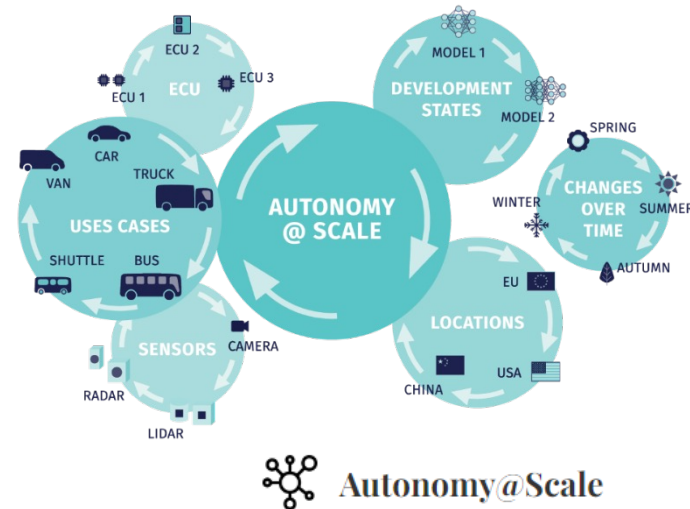
- Launched 2021
- 3rd edition this year
- Now self sustaining, continuation after end of project

ICCV 2021- Workshop on "Embedded and Real-World Computer Vision in Autonomous Driving"

ICCV2021

5 hours workshop with focus on

Embedded AI:

- 3 Keynote Talks
- 3 Paper Sessions
- 5 Poster Presentations

Real-World Computer Vision:

- 1 Keynote Talk
- 3 Paper Sessions

High class speakers from KI Delta Learning and beyond. Video recording available at

https://www.ki-deltalearning.de/event/ercvad2021

Poster and Poster Booklet

Visit around 50 highlight posters in the breaks!

Get a comprehensive overview using our poster booklet with abstracts of all posters and information about the project!
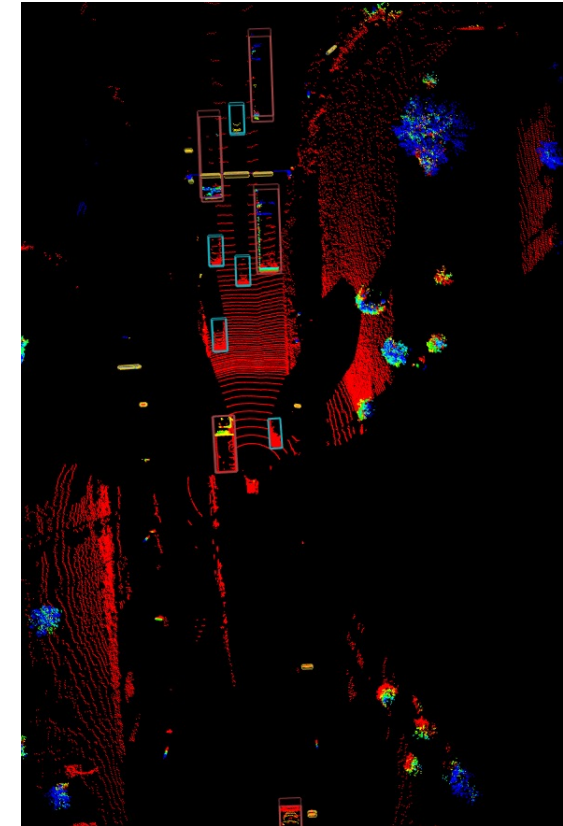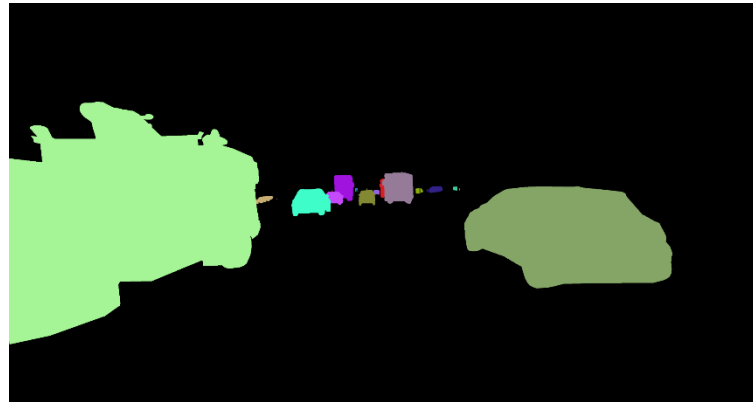
Deliverables

Public versions of Deliverables 11-14 are available at:

https://www.ki-deltalearning.de/downloads

Public versions of the final deliverables will also be disseminated online.

KI-DL Dataset

2D Semantic Segmentation

- *reference: 8.9MP 120° Front-Camera*

2D Instance Segmentation

3D Bounding Box

- *reference: Velodyne 128L 360°*
- including velocity

KI-DL Dataset

193 hours
calibrated and
timestamped
raw data recordings

18,000
annotated real world
single frames

50,000
simulated labeled
frames from CARLA

KIDELTA LEARNING
Scalable AI for Automated Driving

Dr.-Ing. Amin Hosseini | Mercedes-Benz AG

amin.hosseini@mercedes-benz.com

KI Delta Learning is a project of the KI Familie. It was initiated and developed by the VDA Leitinitiative autonomous and connected driving and is funded by the Federal Ministry for Economic Affairs and Climate Action.

KI FAMILIE

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

www.ki-deltalearning.de   @KI_Familie   KI Familie