KI ABSICHERUNG:
SAFE AI FOR AUTOMATED DRIVING

Dr. Sebastian Houben | Fraunhofer Institute for Intelligent Analysis and Information Systems |
The Connected Car and Autonomous Driving, October 26th, 2020

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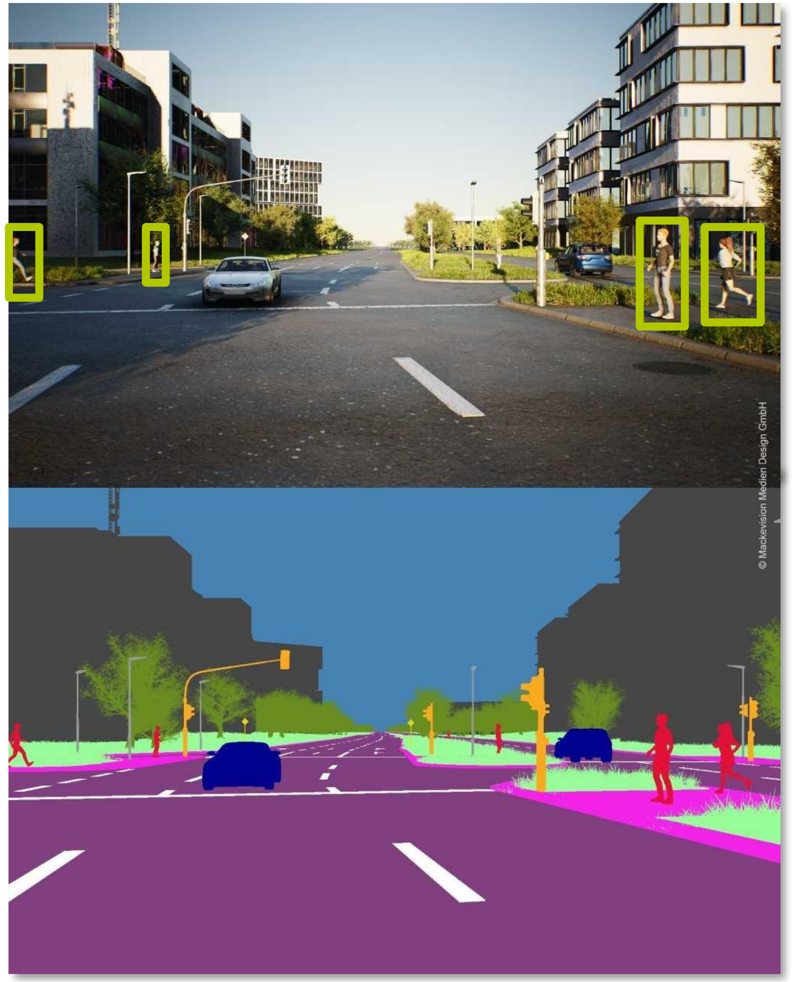
A Modern Application – Autonomous Driving

AI-Based Pedestrian Detection

- Setup
  - An **autonomously operating vehicle** …
  - ... is crossing an **intersection**

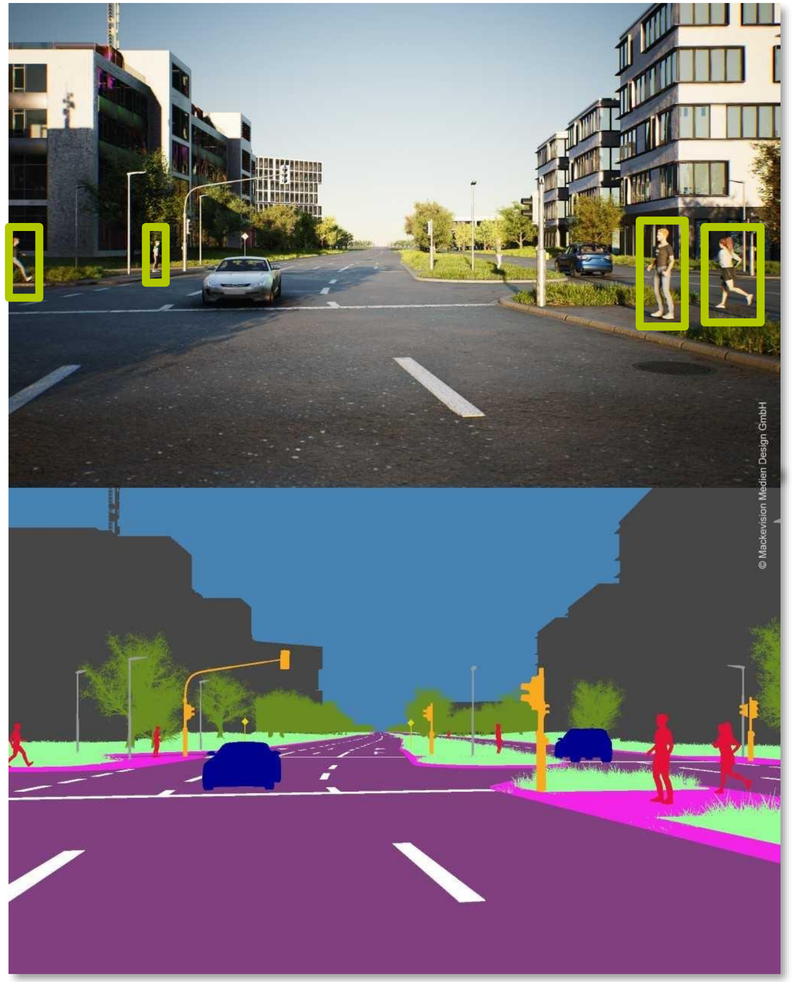
- AI functionality for detecting pedestrians
  - **Camera images** processed by CNN
  - Output
    - Segmentation mask
    - Bounding box detections



Synthetically generated intersection and corresponding semantic segmentation
Project KI Absicherung - https://www.ki-absicherung.vdali.de

Can I Use a State-of-the-Art ML Model in an Automated Vehicle?

- Well, ML models (*safety concerns*)
  - don‘t work well on **unseen data**
  - are not robust to **domain changes**
  - may **overfit** to irrelevant correlations
  - are **overconfident** in their predictions



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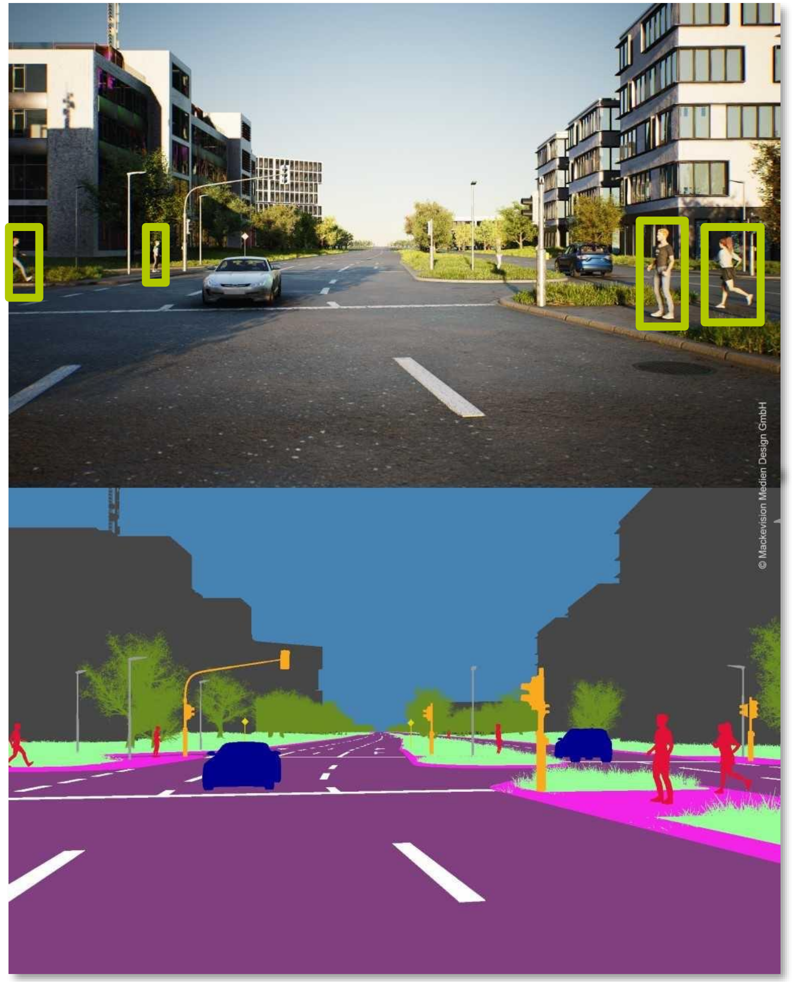
Can I Use a State-of-the-Art ML Model in an Automated Vehicle?

- What can be done?
  - **There are many attempts / research directions to alleviate these concerns.**
  - One of our contributions is to **investigate** some of these methods more deeply.
  - Another one is to **evaluate** them w.r.t. to the saftey concerns
  - and find a **plausible argumentation** that they are circumvented or kept at bay.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KI
ABSICHERUNG
Safe AI for Automated Driving

KI Absicherung is making the safety of AI-based function modules for highly automated driving verifiable.

The Project „KI Absicherung – Safe AI for Automated Driving“

Consortium lead: ***Volkswagen AG***

Deputy consortium lead and scientific coordination: ***Fraunhofer IAIS***

Budget: ***41 Mio. €***

Funding: ***19.2 Mio. €***

Project duration: ***36 months***

2019/01/07 - 2022/20/06

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

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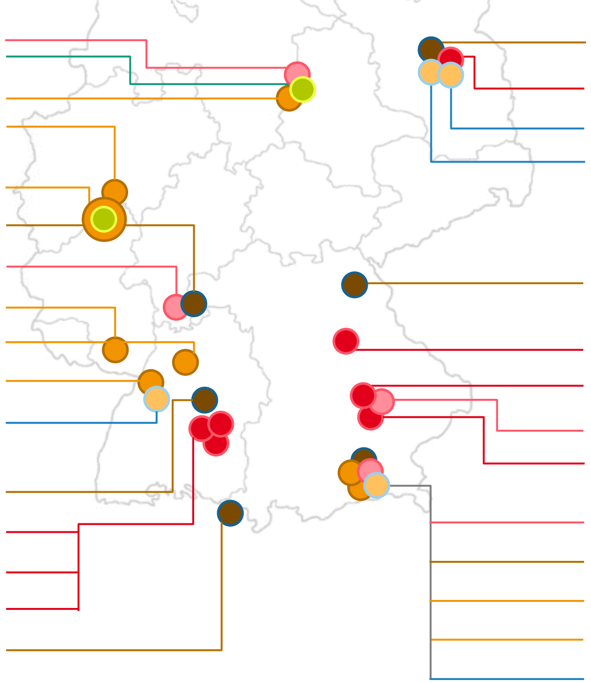

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KI Absicherung

Main Goals

1. Methods for training and testing of AI-based functions

KI Absicherung develops and investigates means and methods for verifying AI-based functions for highly automated driving.

2. Safety argumentation

For the pedestrian detection use case, the project is developing an exemplary safety argumentation and methods for verifying a complex AI function.

3. Communication with standardization bodies on AI certification

The project‘s results will be used in the exchange with standardization bodies to support the development of a standard for safeguarding AI-based function modules.

KI Absicherung

Main Goals

Today‘s Focus

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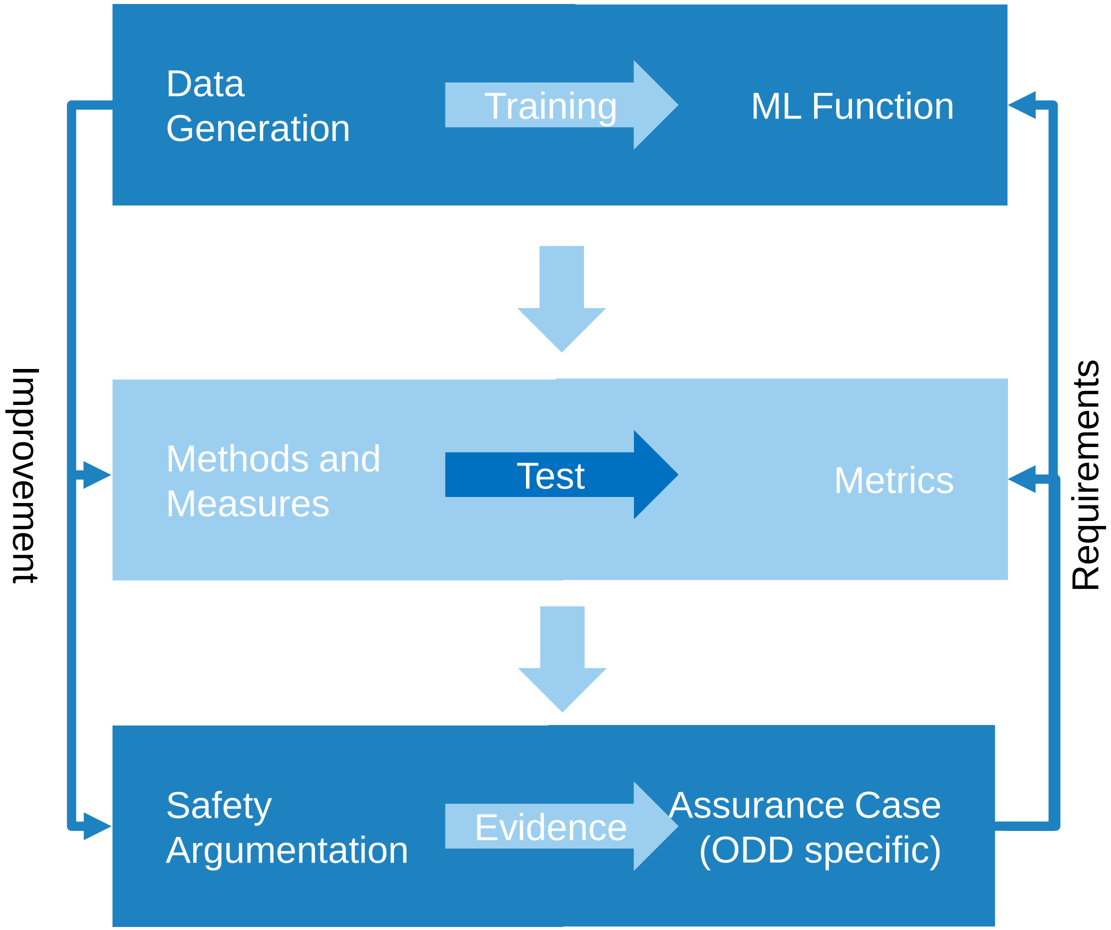
From a Data-Driven AI Function to an Assurance Case

Use Case: Pedestrian Detection

- Process-related generation of synthetic learning, testing and validation data.
- Development of measures and methods that improve the AI function over a wide array of metrics.
- Development and validation of testing methods for these metrics.
- Stringent argumentation for the AI function and its Operational Design Domain (ODD).



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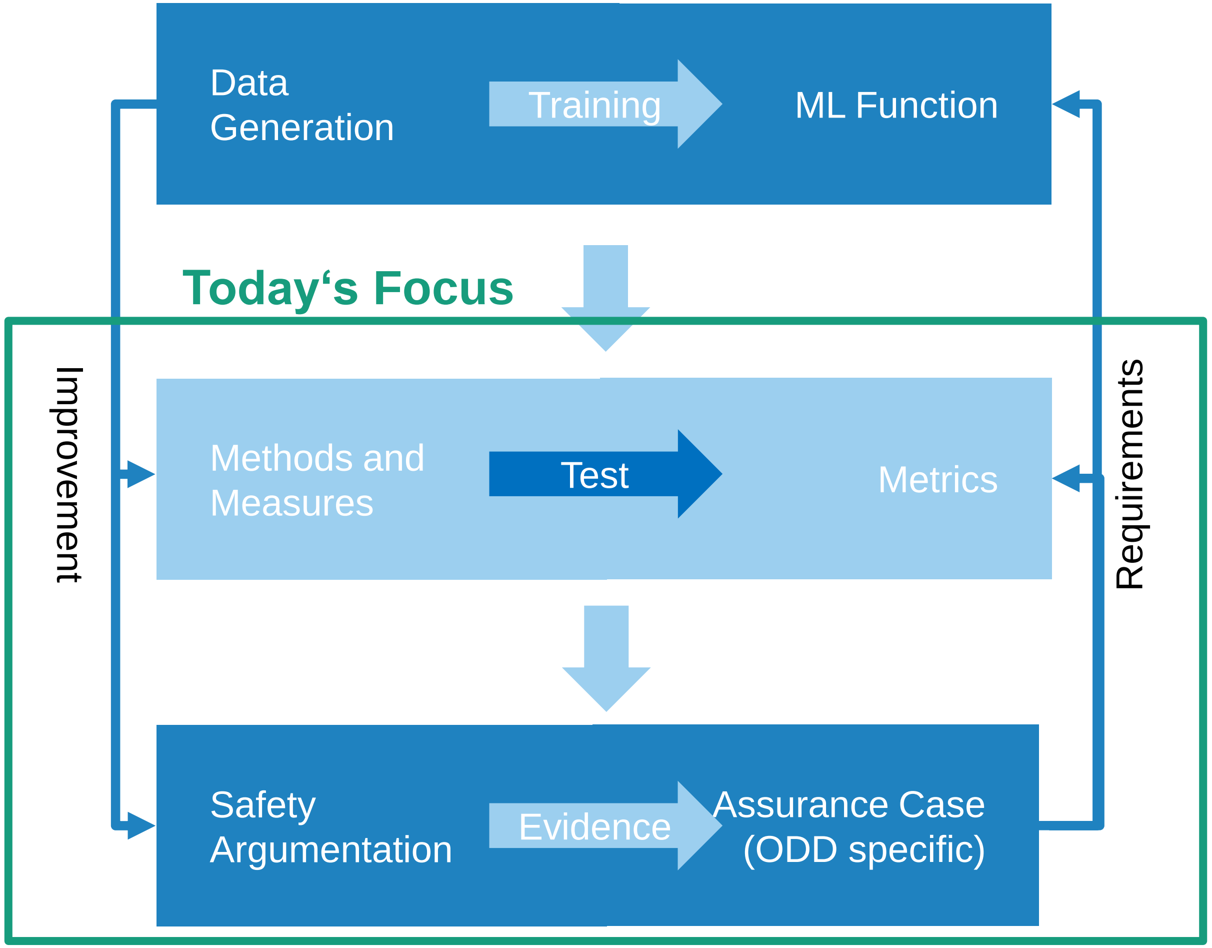
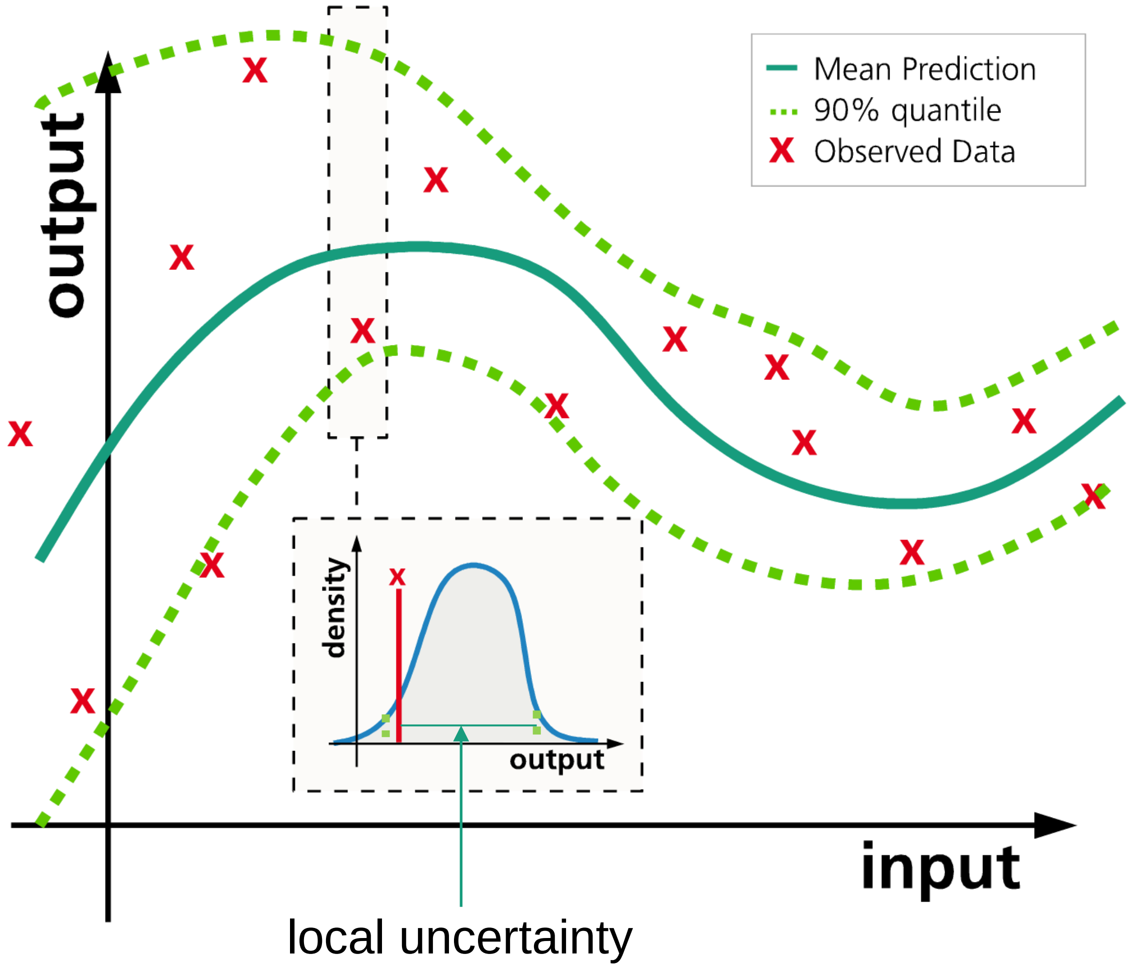


Realistic Uncertainty Estimation

Know If You Know Nothing



local uncertainty

- Local Uncertainty Estimation allows for a **self-assessment** of the neural network given its input, e.g., in order to detect out-of-distribution inputs
- **Increase safety** by discarding uncertain predictions
- **Optimize your dataset** by identifying data points with high uncertainty

Realistic Uncertainty Estimation

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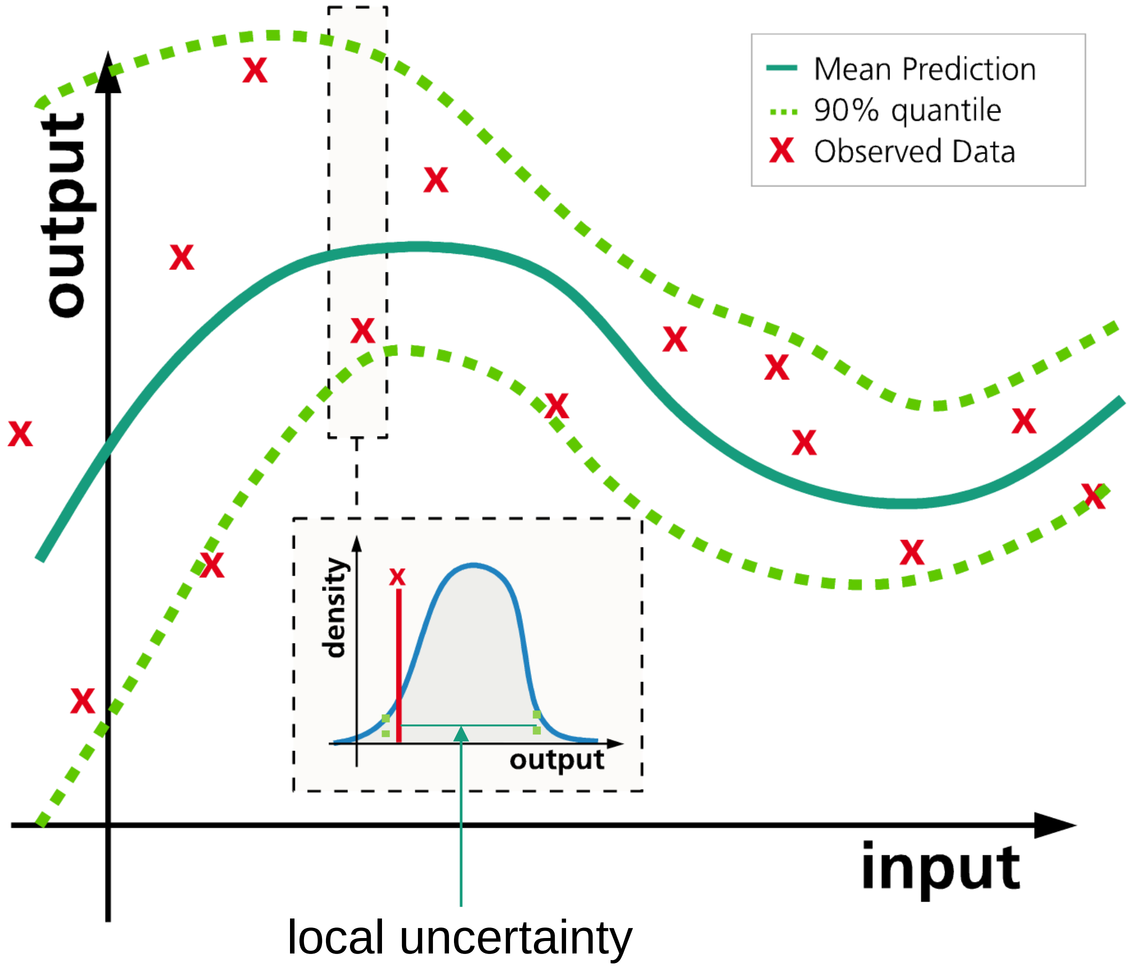
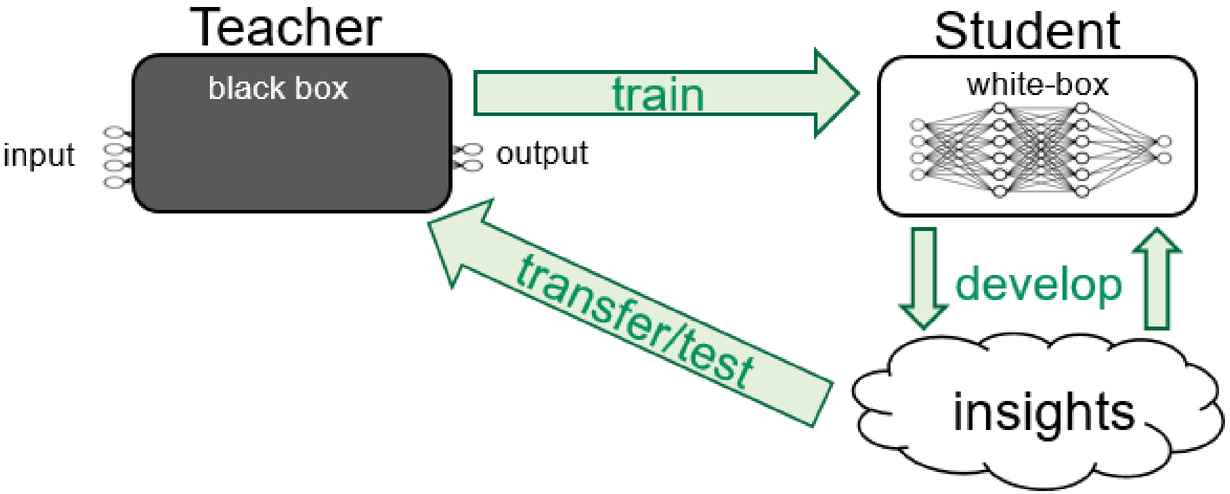


- **State-of-the Art:** Bayesian Networks, Deep Ensembles, MC Dropout
  - **Poorly calibrated:** Predictions are corrected by post processing
  - Yet, realistic local uncertainties are of minor quality
- **Our approach:**
  - Modify the loss function to provide realistic MC Dropout uncertainties
  - Formal understanding and proofs for uncertainty estimation in MC Dropout networks and deep ensembles

Teacher-Student-Methods

Gain Insight into the Inner Workings of a Neural Network

- Derive **interpretable model** (student) from a given black-box-model (teacher)
  - Identify erroneous ”explanations”
  - Does the teacher suffer from the same problem?
- Enables analyses of the teacher model



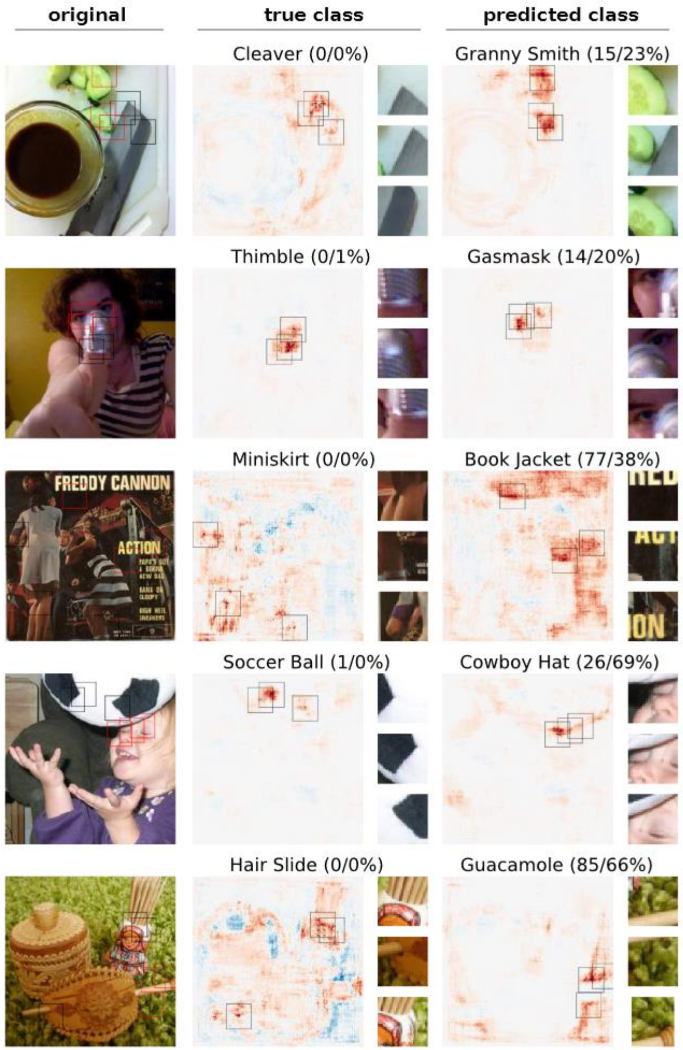


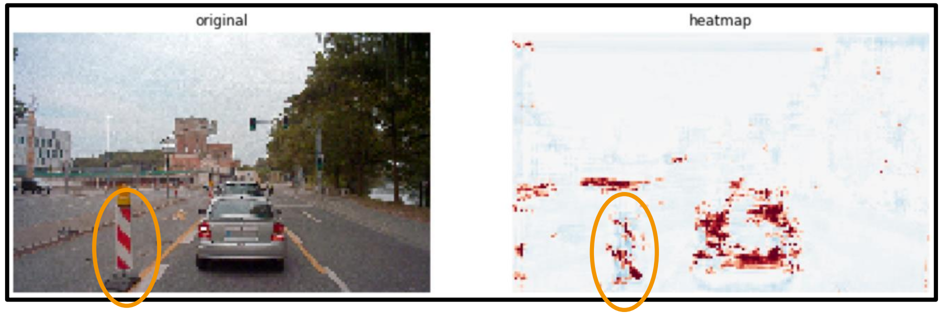
Image: BagNet (arXiv: 1904.00760)

Teacher-Student-Methods

Exploit Identified Insights

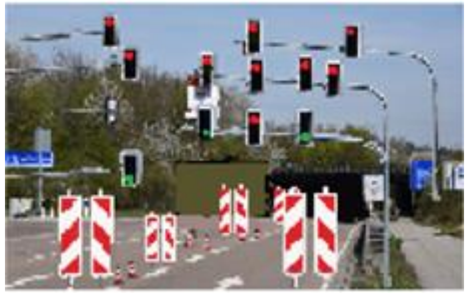
- Derive **interpretable model** (student) from a given black-box-model (teacher)
  - Identify erroneous ”explanations”
  - Does the teacher suffer from the same problem?
- Enables analyses of the teacher model
- By these means we can construct **semantic attacks**

Binary classification: Is there a car in this image?



Student model considers traffic beacon an important hint

Semantic attack: Add traffic beacons to an image



Student model predicts a car in this image

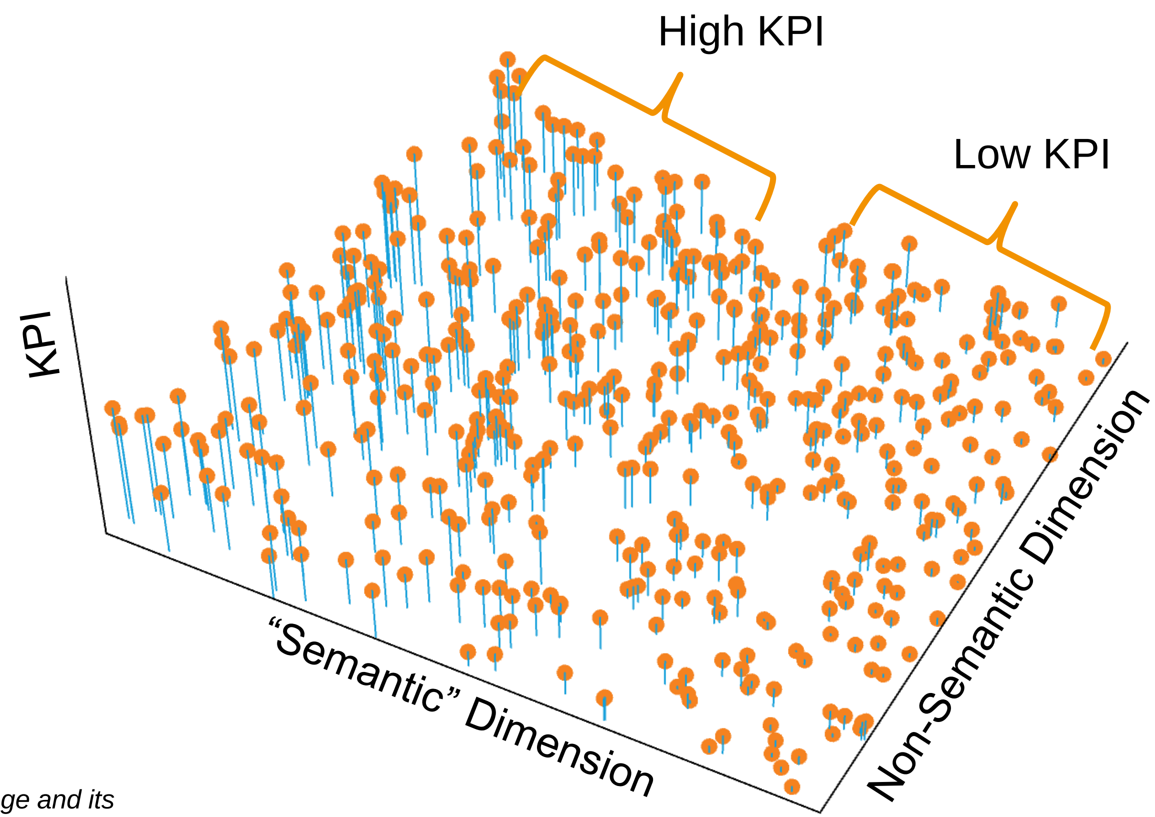
Teacher model (a ResNet) does so, too.

Assess Test Data Completeness

Find Situations with Systematically Low Performance

- Find correlations among **semantic concepts** (e.g., position / size of pedestrians)
  - and poor model performance
  - or pronounced and distinct safety concerns

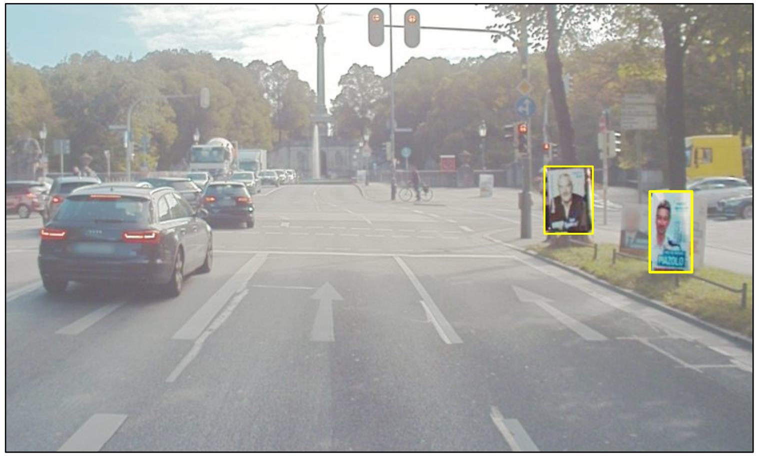
- Reveal situations with poor prediction performance
- Reveal poor training procedures
  - E.g., with **Neuron Coverage** (Percentage of neurons that are sufficiently activated by at least one test example)



Abrecht, Akila, Gannamaneni, Groh, Heinzemann, Houben, Woehrle, *“Revisiting Neuron Coverage and its Application to Test Generation”, Third International Workshop on Artificial Intelligence Safety Engineering, SAFECOMP WAISE, 2020 (Best Paper Award)*

Evaluation of Dependencies between Neural Networks and Data
Visual Interactive Analysis of Semantic Features

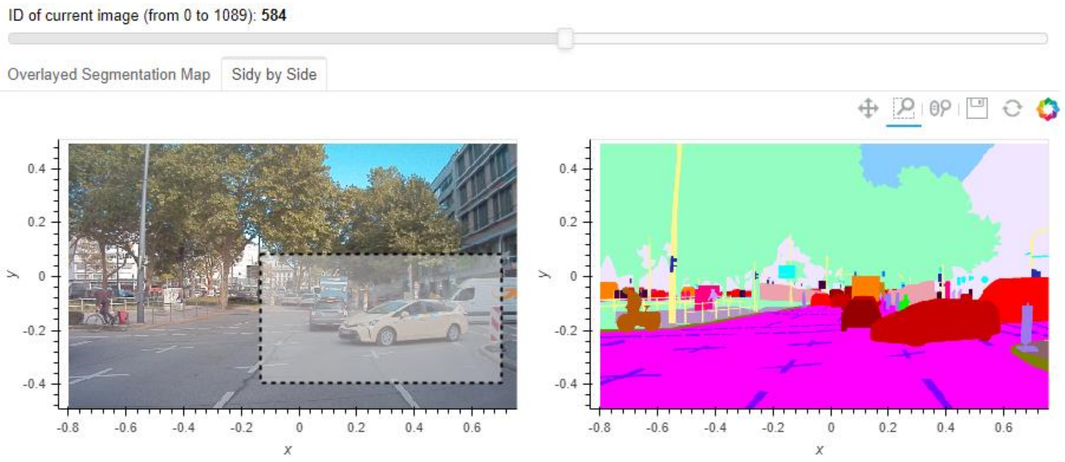
- **Goal:** finding correlated insufficiencies and gaining **insight into the decision of networks**
- Understanding semantic concepts of the data is the key to **identifying & distinguishing outliers from systematic weaknesses** (like shortcuts or data flaws)
  - But: automated analysis of semantics is difficult
  - Those **semantic features** are examined best visually by humans



Evaluation of Dependencies between Neural Networks and Data

Finding Semantic Clusters in a Visual Interactive Interface

- Specific focus on enabling the human expert to:
- Interactively analyze the **KPIs w.r.t. robustness**
- Inspect image data sets to **gain insights**
  - E.g. into important image parts, hard or underrepresented images/image scenes ("corner cases"), unusual object appearances, data flaws etc.



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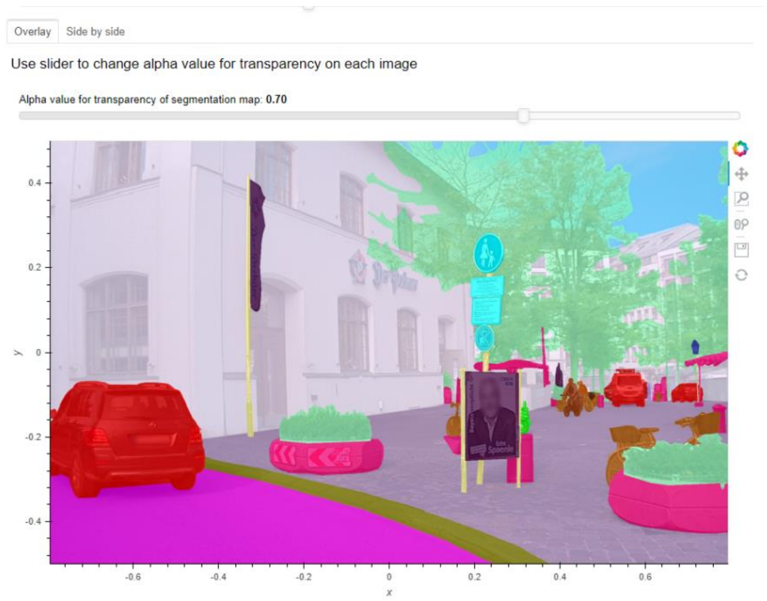


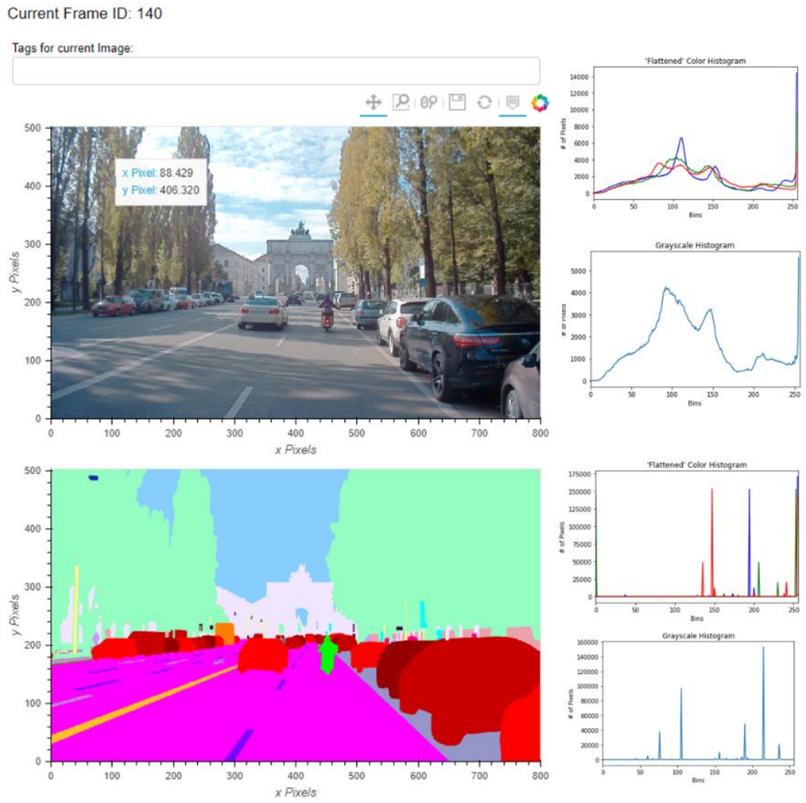
Use slider to change alpha value for transparency on each image

Alpha value for transparency of segmentation map: **0.70**

Evaluation of Dependencies between Neural Networks and Data

Finding Semantic Clusters in a Visual Interactive Interface

- Enabling the human to **understand semantic concepts of the data** with additional information
  - E.g. metadata, histogram data
- Identify **semantic clusters**
  - Use VA to develop metrics incorporating **human semantic understanding** and DNN performance measures
  - E.g. by textual and visual querying (“query by example”) and filtering
  - E.g. tagging, sorting and searching images



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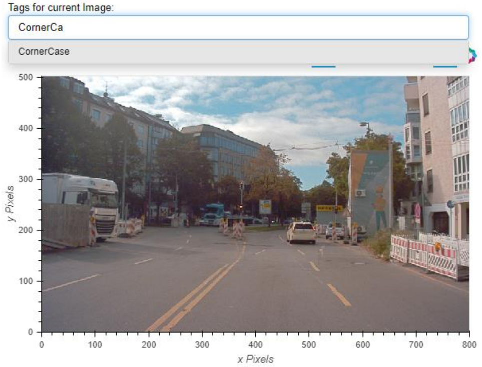

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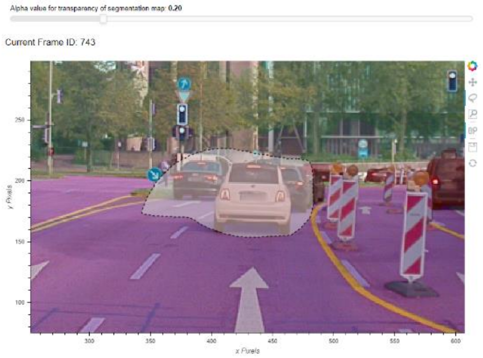
CornerCase



Alpha value for transparency of segmentation map: 0.20

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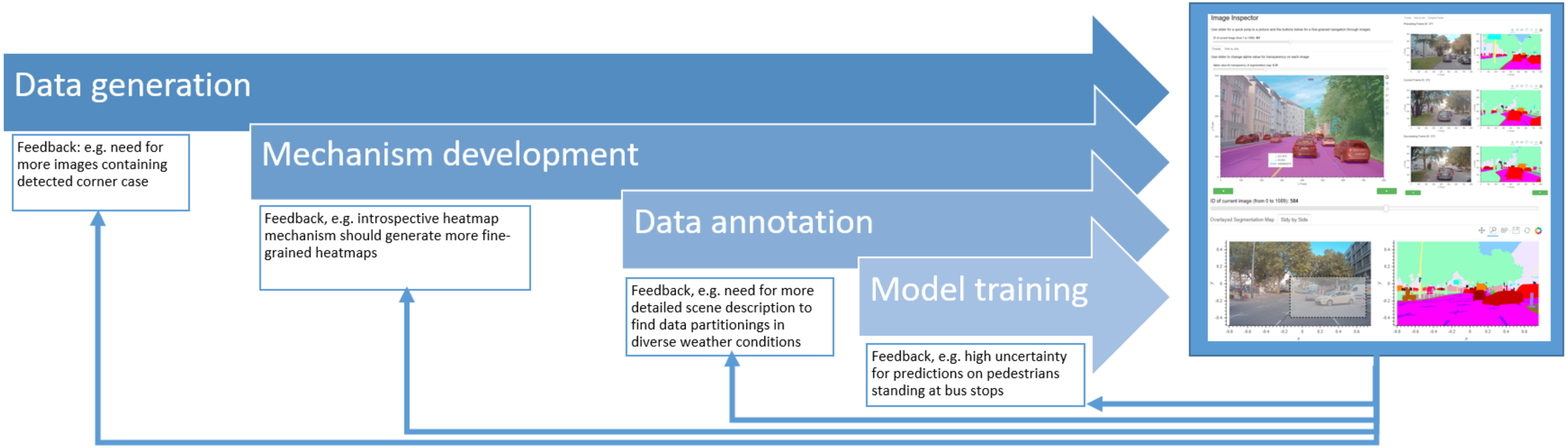
Evaluation of Dependencies between Neural Networks and Data

Establishing a Feedback Loop

- These **insights** can then in turn be used to **enhance**
  - The **training methods** of the neural networks
  - The **data set generation**
- Establishing a **feedback loop** between data generation, neural network training and analyses of both



Feedback: e.g. need for more images containing detected corner case

Feedback, e.g. introspective heatmap mechanism should generate more fine-grained heatmaps

Feedback, e.g. need for more detailed scene description to find data partitionings in diverse weather conditions

Feedback, e.g. high uncertainty for predictions on pedestrians standing at bus stops

Image Inspector

Use slider for a quick jump to a picture and the buttons below for a fine-grained navigation through images.

Use slider to change alpha value for transparency on each image

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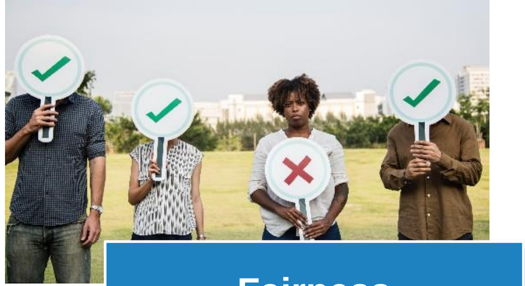
Beyond Absicherung

Typical Challenges of the Individual Audit Areas

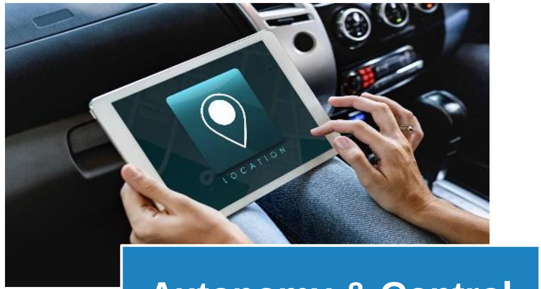
Ethics & Law

Key questions concerning ethical issues



Fairness

Historically unbalanced data



Autonomy & Control

Appropriate degree of autonomy

Transparency

Incomprehensibility of results from neural networks

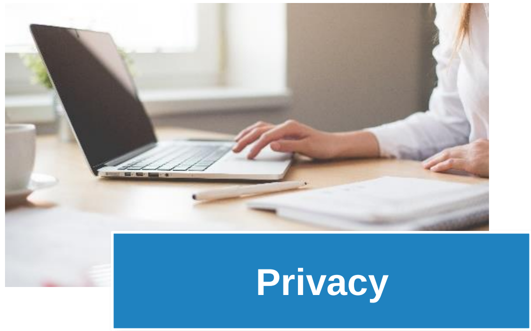
Today‘s Focus

Reliability

Robustness of results processed by AI-systems

Safety & Security

Safety risks due to probabilistic output from AI component



Privacy

New types of personal data through AI

Certifying Artificial Intelligence

Whitepaper Points out Audit Areas

- Collaboration of experts from Fraunhofer IAIS, Univ. Bonn and Univ. Cologne from the fields of
  - Machine Learning
  - Law
  - Ethics
  - IT Security
- Interdisciplinary initiative funded by the competence platform KI.NRW
- Audit areas for trustworthy AI
- **www.iais.fraunhofer.de/ki-zertifizierung**

Publication with high international attention

Fraunhofer IAIS

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VERTRAUENSWÜRDIGER EINSATZ VON KÜNSTLICHER INTELLIGENZ

HANDLUNGSFELDER AUS PHILOSOPHISCHER, ETHISCHER, RECHTLICHER UND TECHNOLOGISCHER SICHT ALS GRUNDLAGE FÜR EINE ZERTIFIZIERUNG VON KÜNSTLICHER INTELLIGENZ

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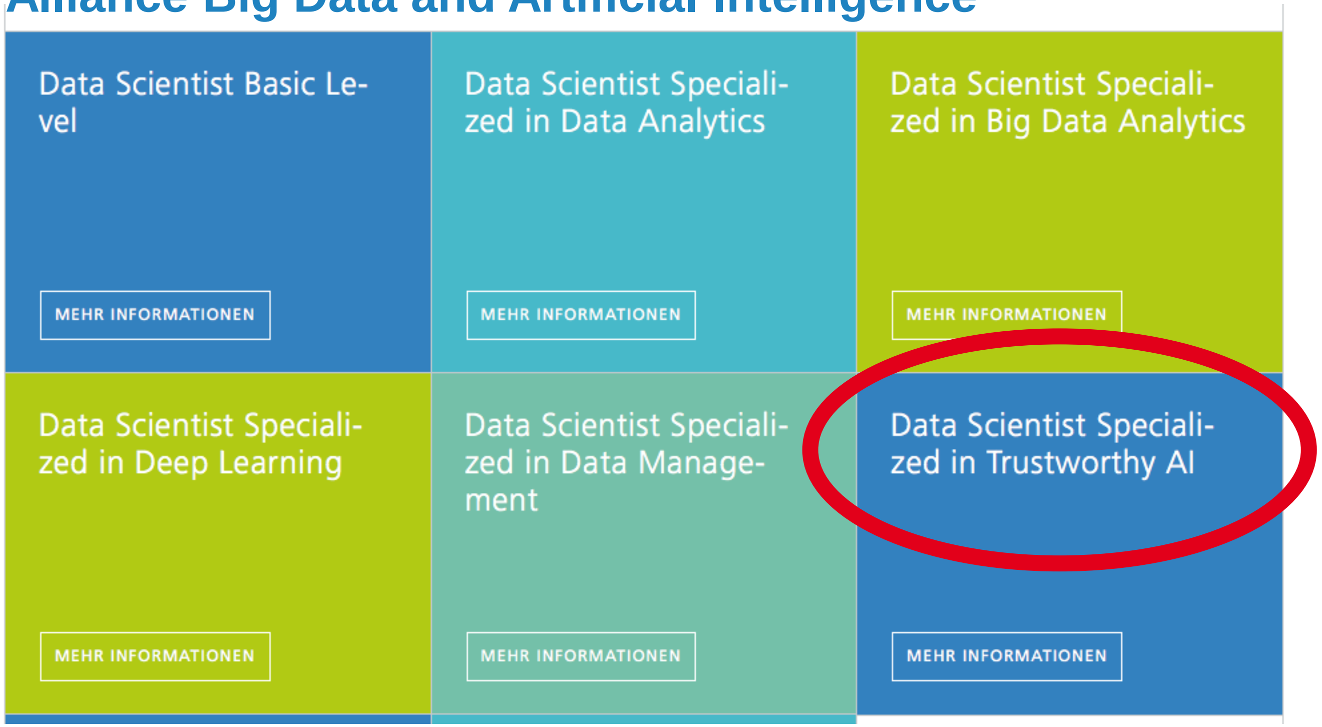
  - Methods for assessing and verifying AI applications
- Project „KI-Absicherung“
  VDA Leitinitiative
  “Autonomous and Connected Driving“
  www.ki-absicherung.vdali.de
- Point of contact: PD Dr. Michael Mock
  michael.mock@iais.fraunhofer.de

Data Scientist Advanced Trainings at Fraunhofer-Alliance Big Data and Artificial Intelligence



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THANK YOU FOR YOUR ATTENTION

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The Connected Car and Autonomous Driving, October 26th, 2020

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