Context Aware Data Reduction for Highly Automated Driving

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MASCHINENBAU
We engineer future

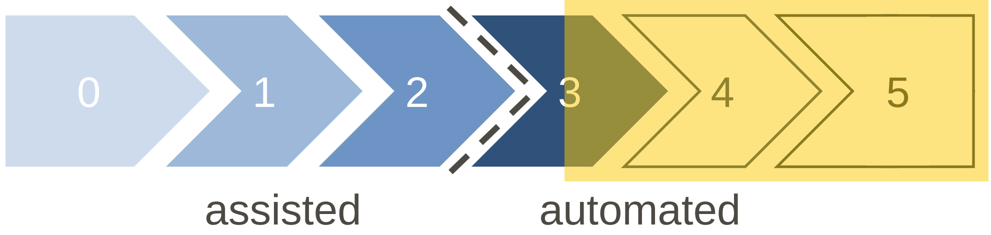
FZD

Motivation

Automated Driving (AD)

- brings …
  - safety
  - efficiency
  - availability
  - comfort

SAE levels for AD



Challenges

- **Data amounts**
  - ~10 TB/h for AD → ~10 ZB to release

- **Open Context**
  - What is relevant?


Source: Cityscapes

Agenda

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State of the art

Research Questions

Relevance | Data Reduction

Method

Evaluation

Results

Outlook

State of the art

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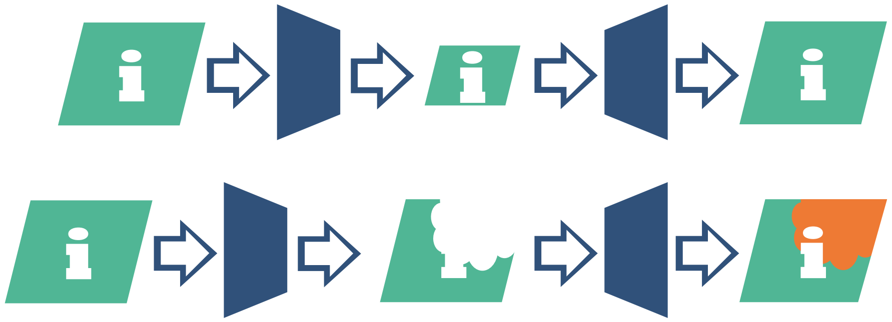
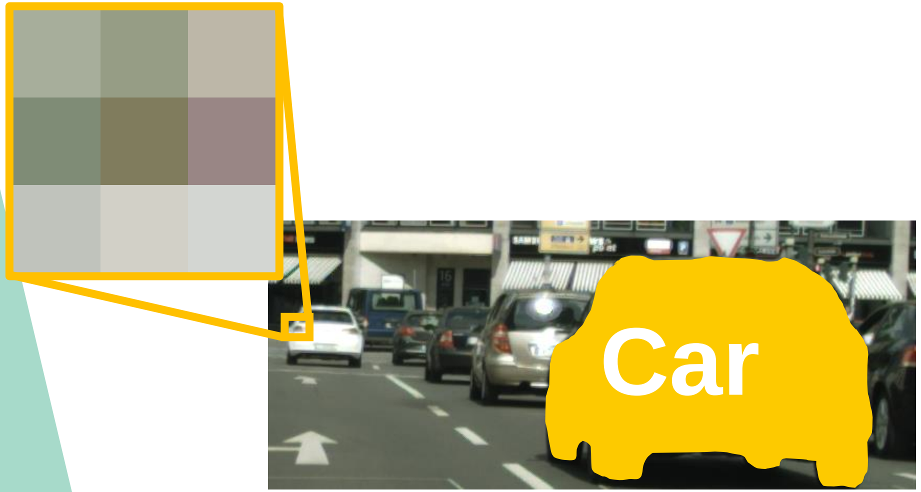
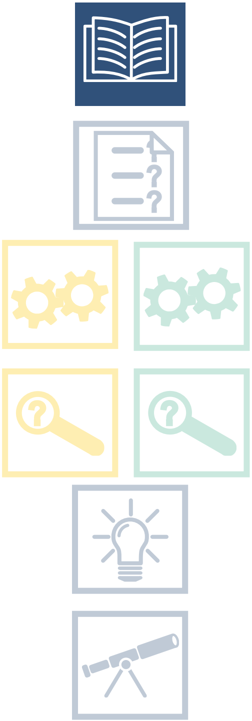
Data reduction for AD

- **Lossy or Lossless**
- **Low-Level features**
  - e.g. Pixel
  - Technology far advanced
- **High-Level features**
  - Simple methods (Triggering)
  - Missing use of domain knowledge for AD







Research Questions

1. How can the open context present in automated driving be addressed in data reduction?

2. How can relevance be formally defined to facilitate its use in data reduction?

3. What is the impact of this data reduction method on the performance of subsequent use cases?

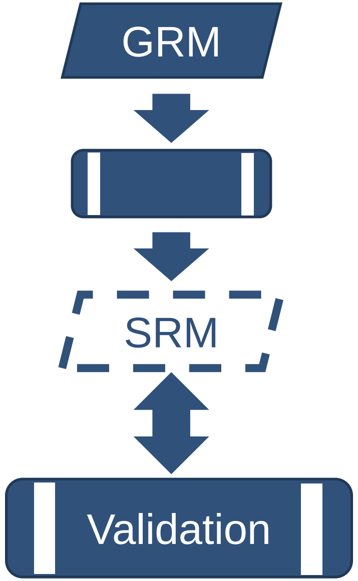
Relevance: Method

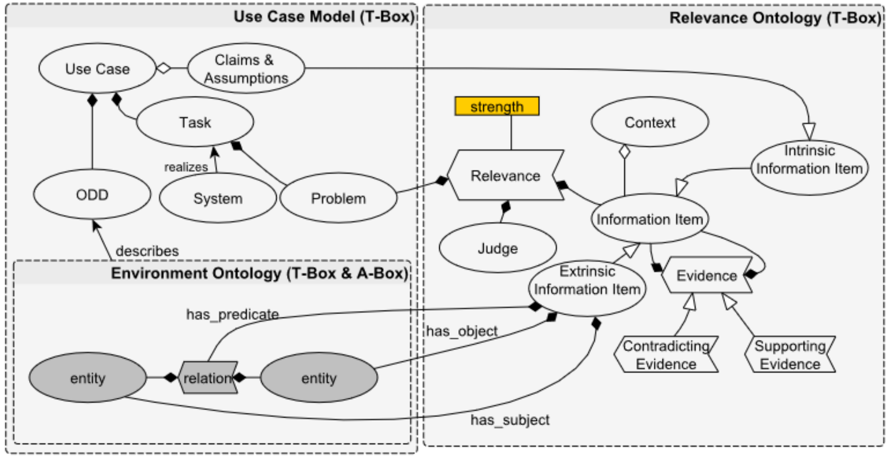
General Relevance Model (GRM)

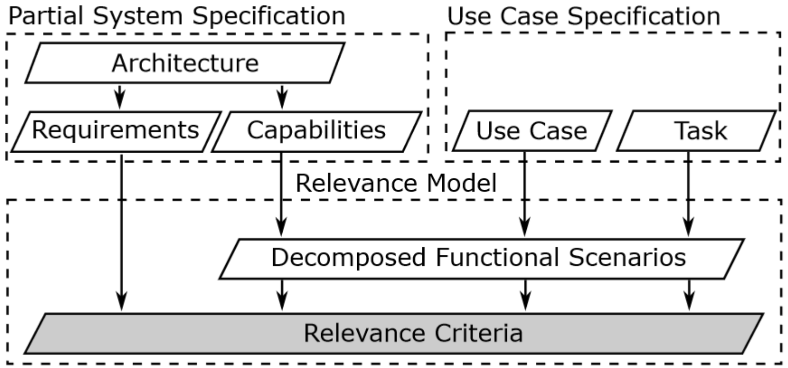
- Abstract description using ontologies

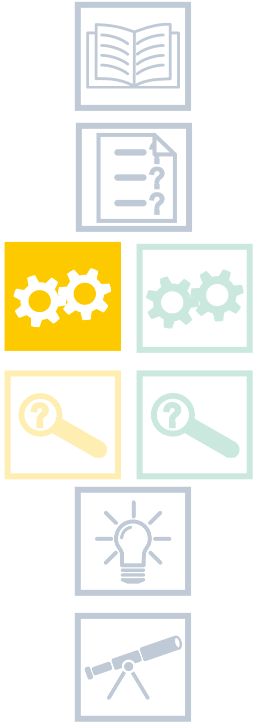
Specific Relevance Model (SRM)

- Use Case specific implementation details









Relevance: Method

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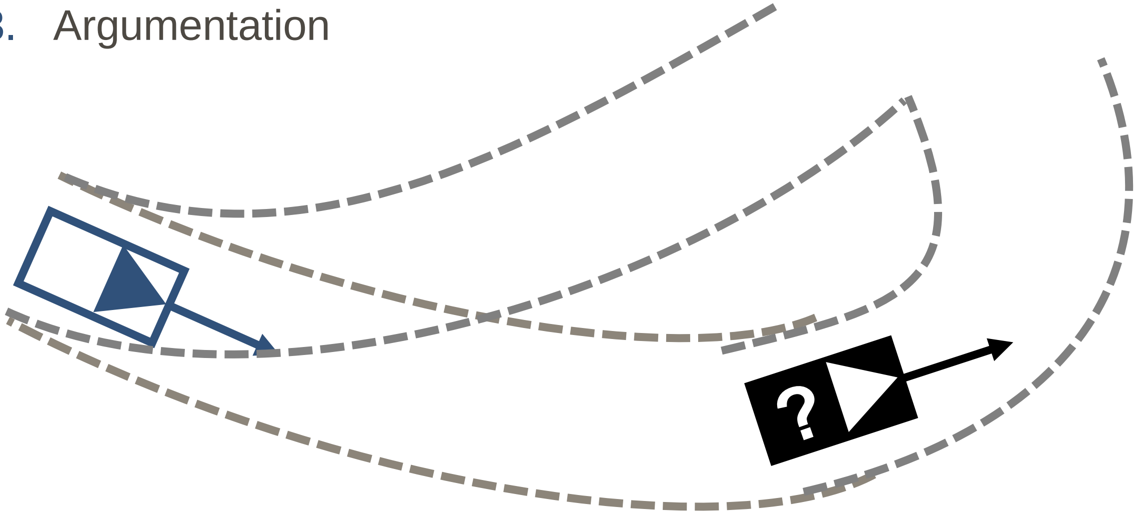
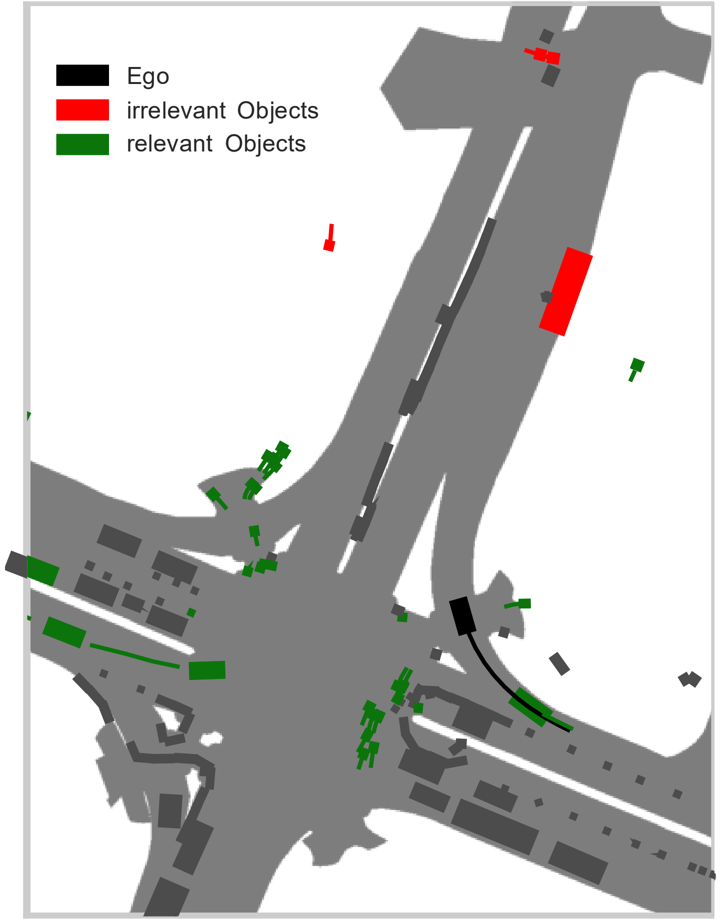
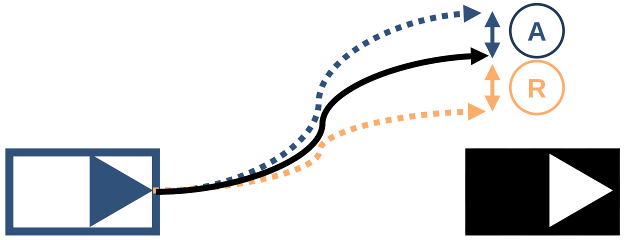
Proof of Concept

- Perception relevance for collision free driving
- Three principles
  1. Worst-Case assumption
  2. Superposition
  3. Argumentation



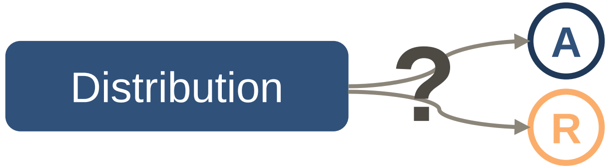


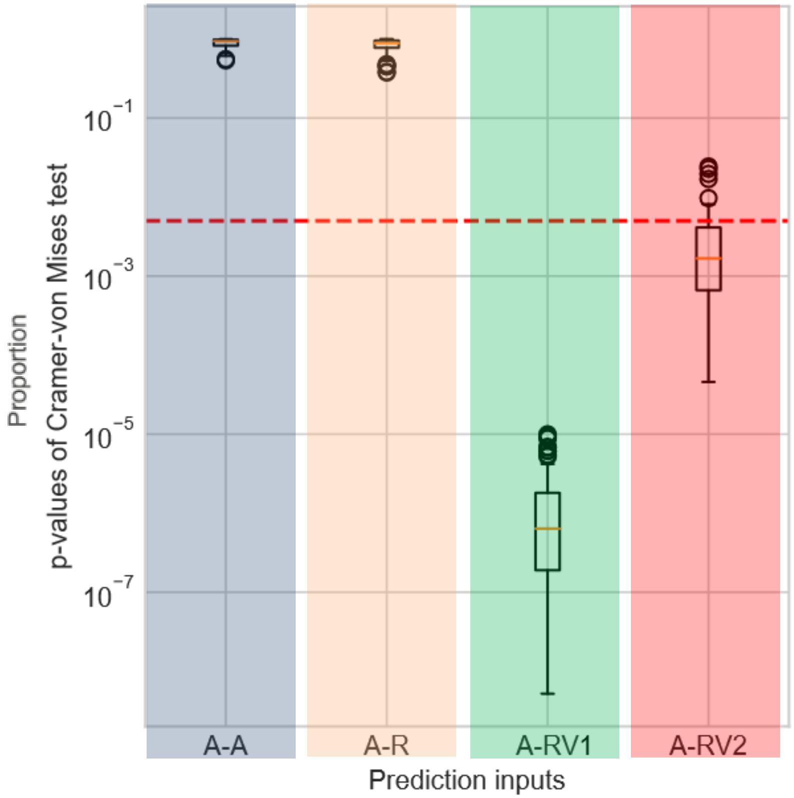
Relevance: Evaluation

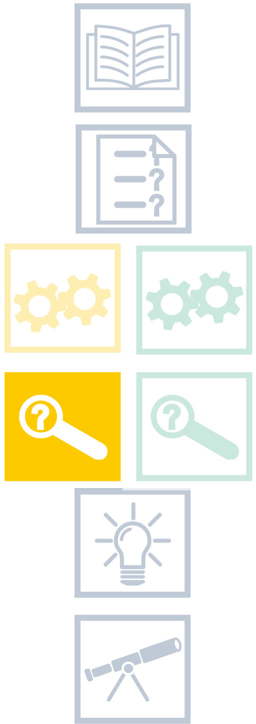


Validation Concept

- Reference: human driver
- Compare Ego prediction with different information
- Aggregation of prediction errors
- Cramer-von Mises Test:



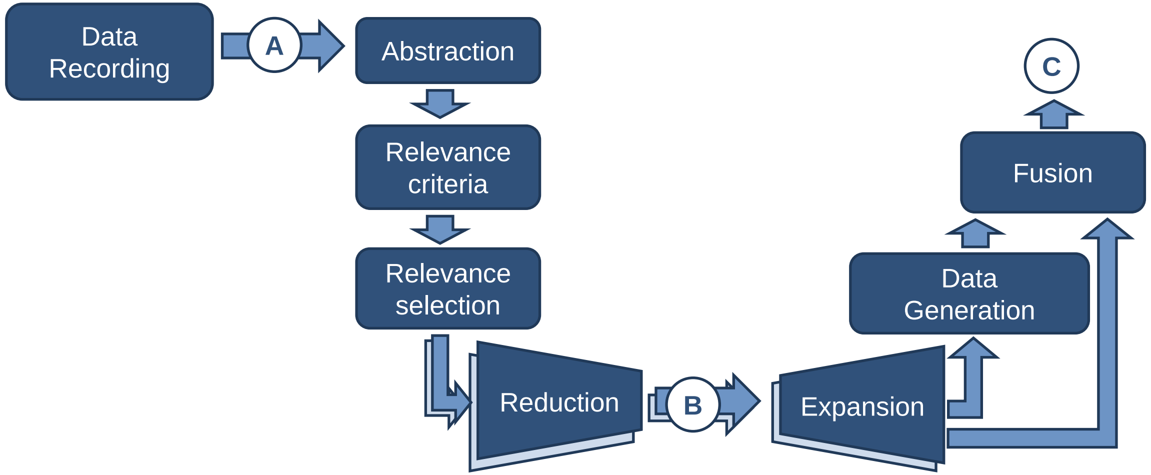


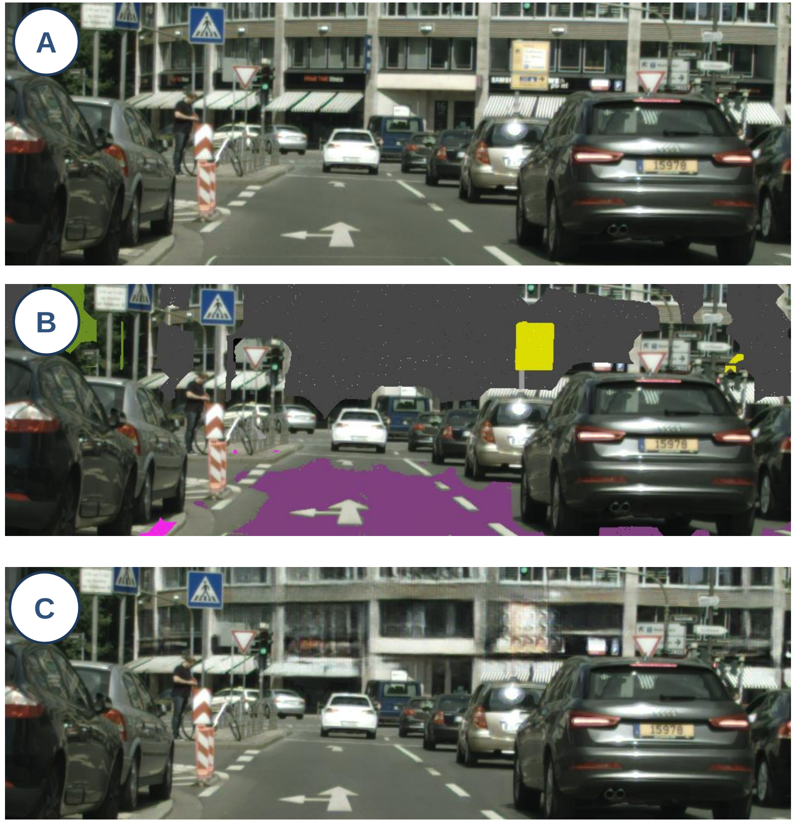


Data Reduction: Method

Concept

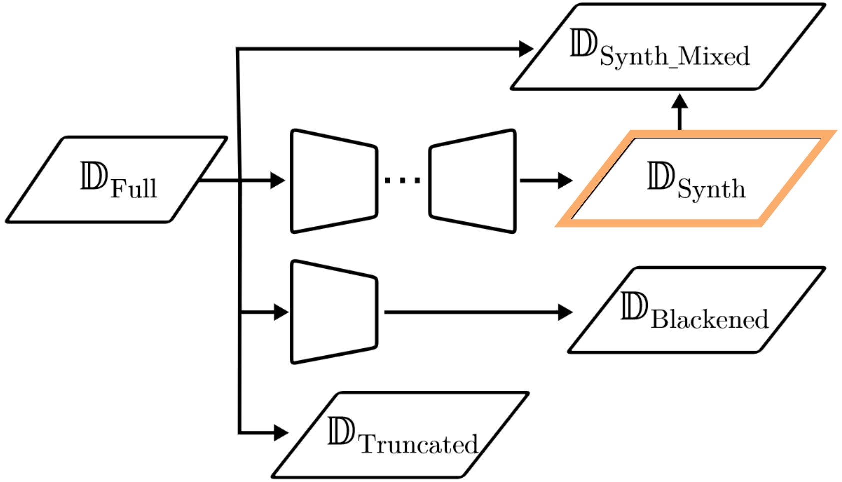
- Reduction by abstraction
- Expansion by “plausible lie”
- Relevant information left unaltered

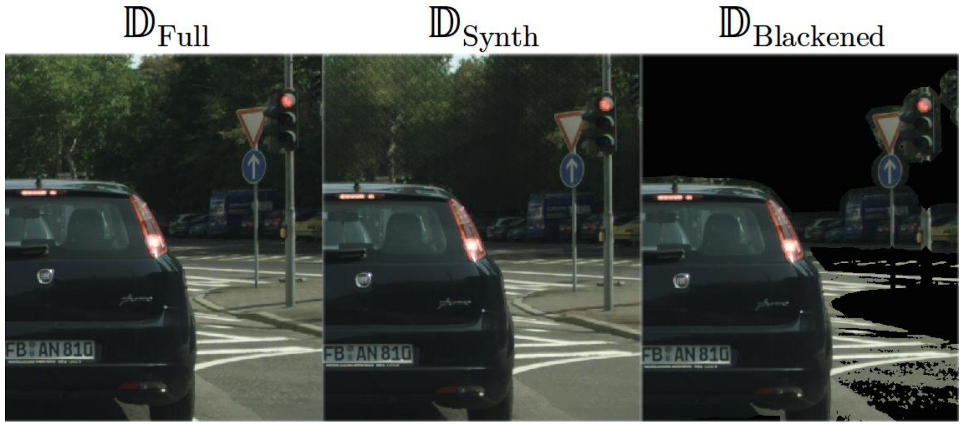




Data Reduction: Evaluation

- Impact on Neural Nets
  - Inference | Training
  - Object detection | Semantic segmentation
- 5 datasets for evaluation





Data Reduction: Evaluation

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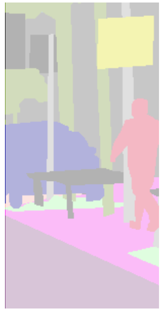
Inference

- Proposed method $\mathbb{D}_{\text{Synth}}$:
  - Small impact on performance
- Alternative method $\mathbb{D}_{\text{Blackened}}$:
  - Large impact on performance

→ „Plausible lie“ of irrelevant information essential for inferenz



Semantic segmentation (mIoU)

	$\mathbb{D}_{\text{Full}}$	$\mathbb{D}_{\text{Synth}}$	$\mathbb{D}_{\text{Blackened}}$
Relevant Ø	0,823	0,819	0,37
Irrelevant Ø	0,79	0,72	-
Ø	0,81	0,78	-

Object detection (mAP_{50})

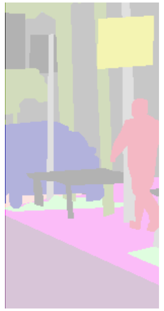
	$\mathbb{D}_{\text{Full}}$	$\mathbb{D}_{\text{Synth}}$	$\mathbb{D}_{\text{Blackened}}$
Relevant Ø	0,373	0,369	0,14

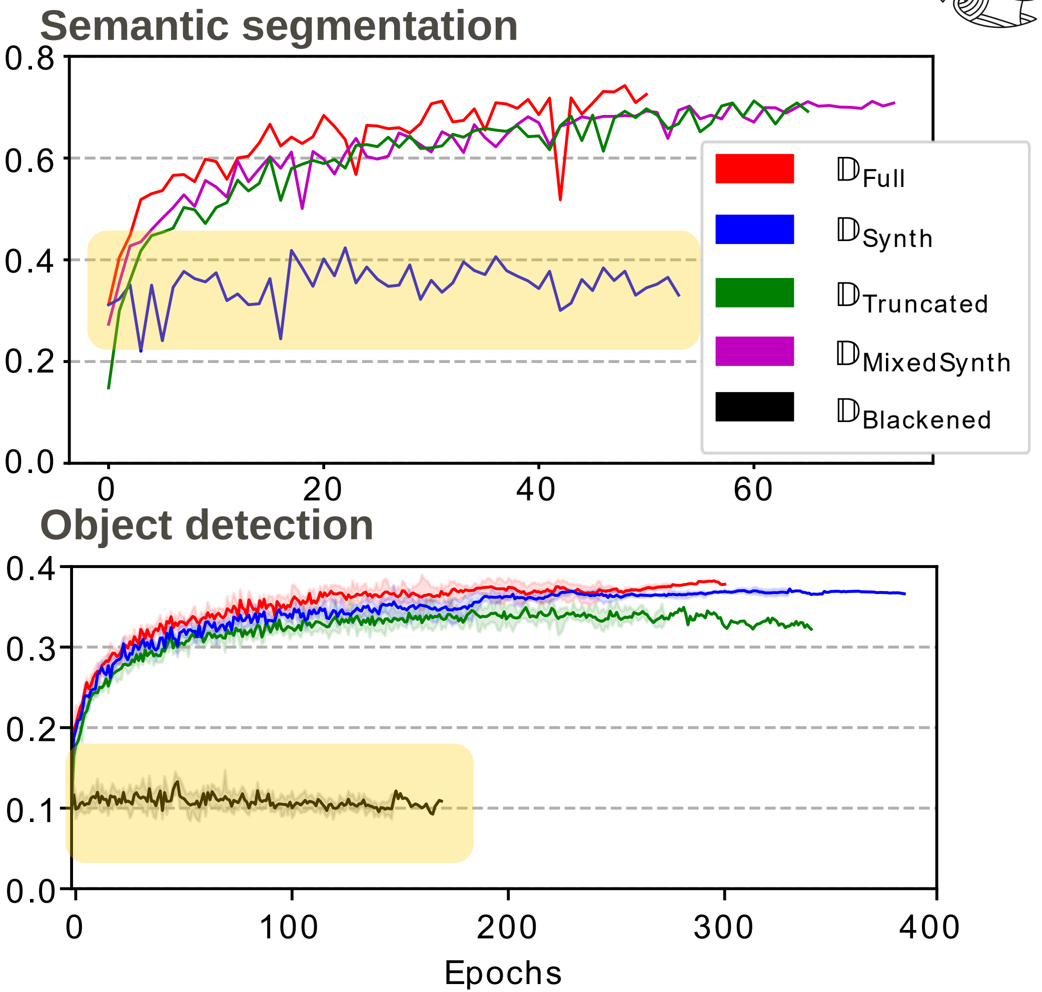
Data Reduction: Evaluation

Training

- ✗ Semantic segmentation
- ✓ Object detection

→ Dependent on Use Case





→ „Plausible lie“ of irrelevant informatio essential for training

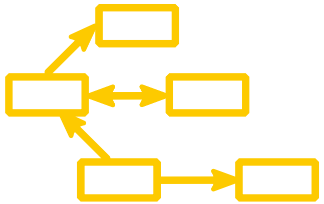
Results

1. Data reduction for open context?

Inclusion of domain-specific relevance

→ Control of information losses

→ Effective management of performance losses

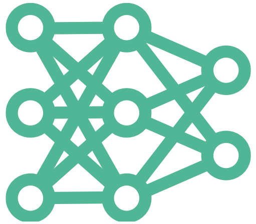


2. Description of relevance?

Ontological models

→ Adaptive modeling for different relevance concepts

→ Derivation of relevance from knowledge representation



3. Impact on performance?

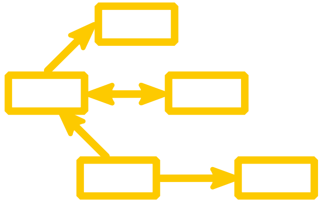
→ Suitability for inference and training of neural networks

→ Dependence on the use case

Outlook

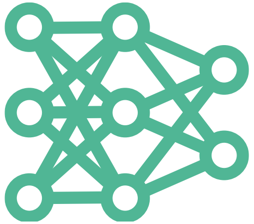
1. Relevance-driven data reduction

- Common representation of various sensor modalities
- Enhanced understanding of use case dependency



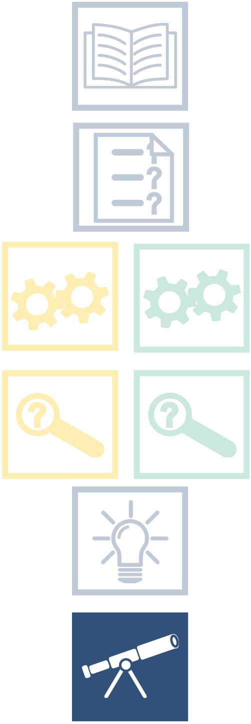
2. Relevance modeling

- Establishment of differentiated relevance consideration in AD
- Standardized concepts and nomenclature for relevance in AD



3. Application

- Previously "laboratory conditions"
- Possible application modes?
- Transferability/scaling to industrial application?



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Thank you

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