KI WISSEN
Automotive AI Powered by Knowledge

KI Wissen Final Event | 21-22 March 2024

Knowledge Integration

Jörg Reichardt | Continental

1

Knowledge is …

What is knowledge in the automotive context?

- *„Knowledge*

  *… is the familiarity or awareness of something such as facts (descriptive knowledge), skills (procedural knowledge), or objects (acquaintance knowledge) contributing to ones **understanding**.”* (Wikipedia)

- **„Understanding**

  *… implies abilities and dispositions with respect to an object of knowledge that are sufficient to support **intelligent behaviour**.” (ibid)*

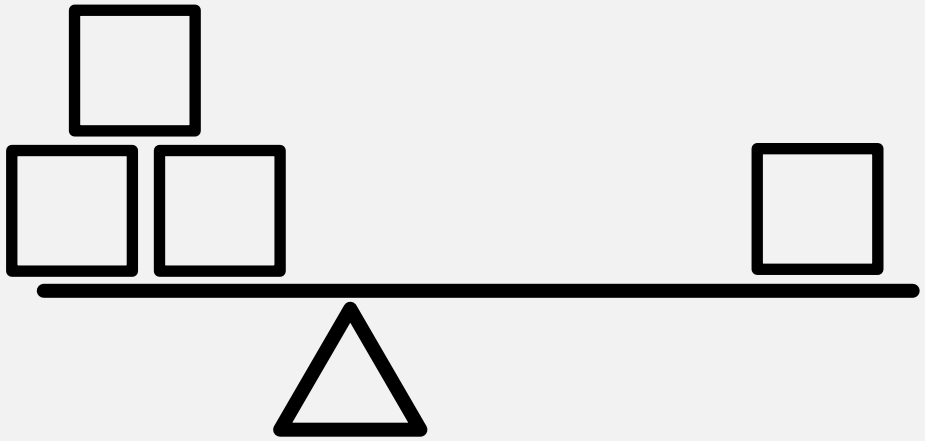
- **Knowledge allows us to drive safely.**

The challenge: Diversity and Uncertainty of Facts and Objects …

… must be reigned in by Rules and Constraints.

i.e., Mathematical and Physical Knowledge

solid facts, not open for interpretation and independent of situational context



AP 1.3

i.e., Normative Rules and Regulations

soft facts that require interpretation in a situational context

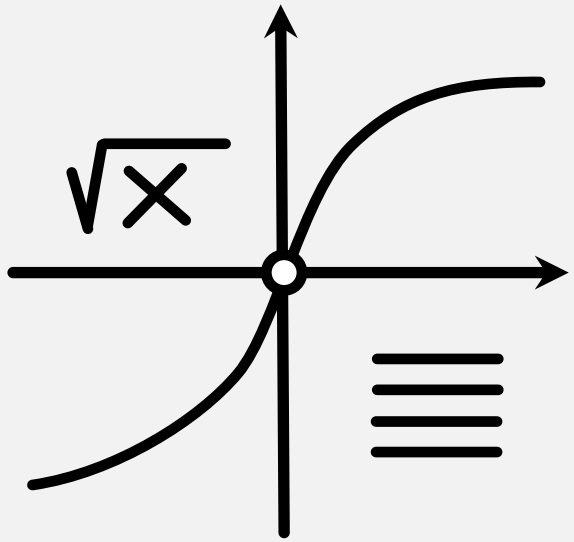
AP 1.4

2

No Integration without Representation!

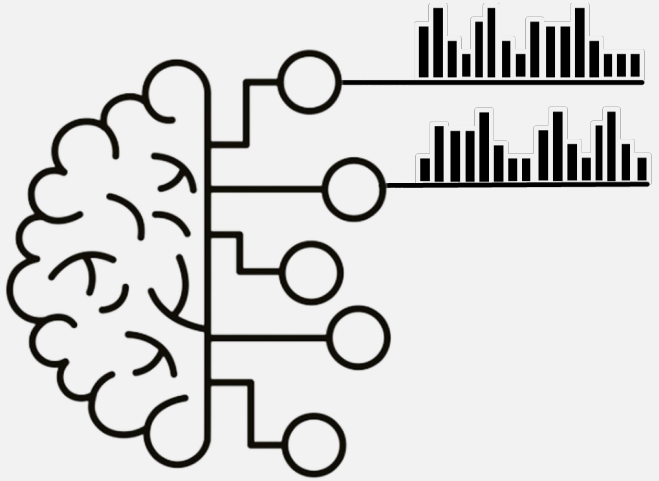
Explicit and Implicit Knowledge Representation

Explicitly as Symbolic Knowledge



Neural Representation (Embedding)
or mathematical formulas & constraints

Implicitly in Connectionist Architectures

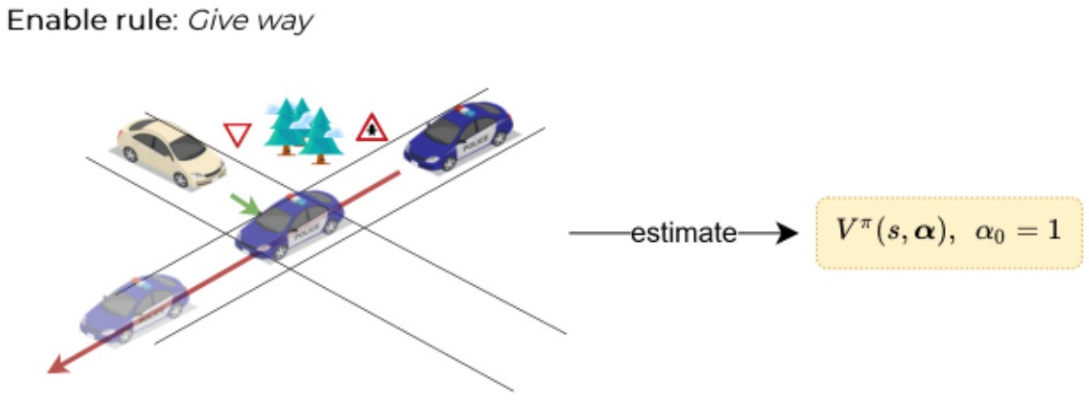


Interpretable Neural Activity

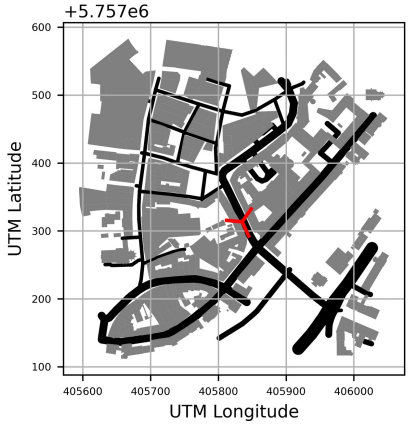
AP 1.5

AP1.5 – Knowledge Building Blocks

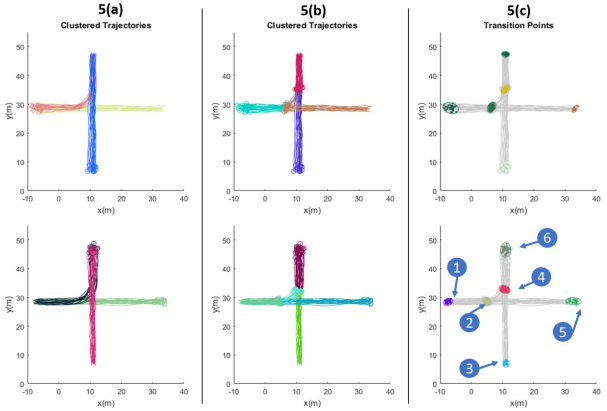
- Motivation: Different Knowledge Sources and Representations among partners:



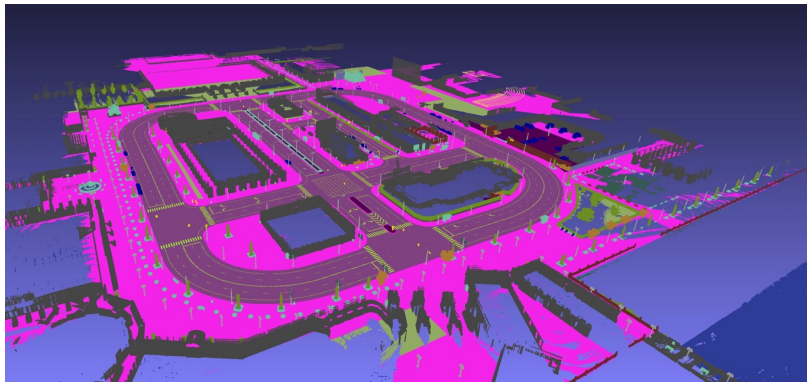
Traffic Rules



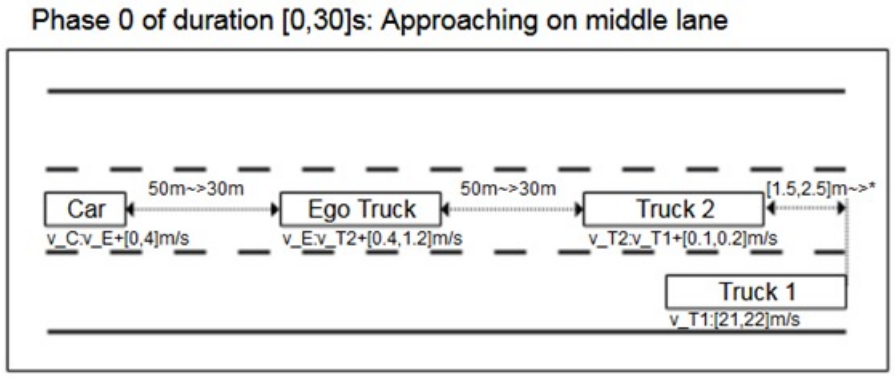
Street Configuration



Typical Pedestrian Behavior



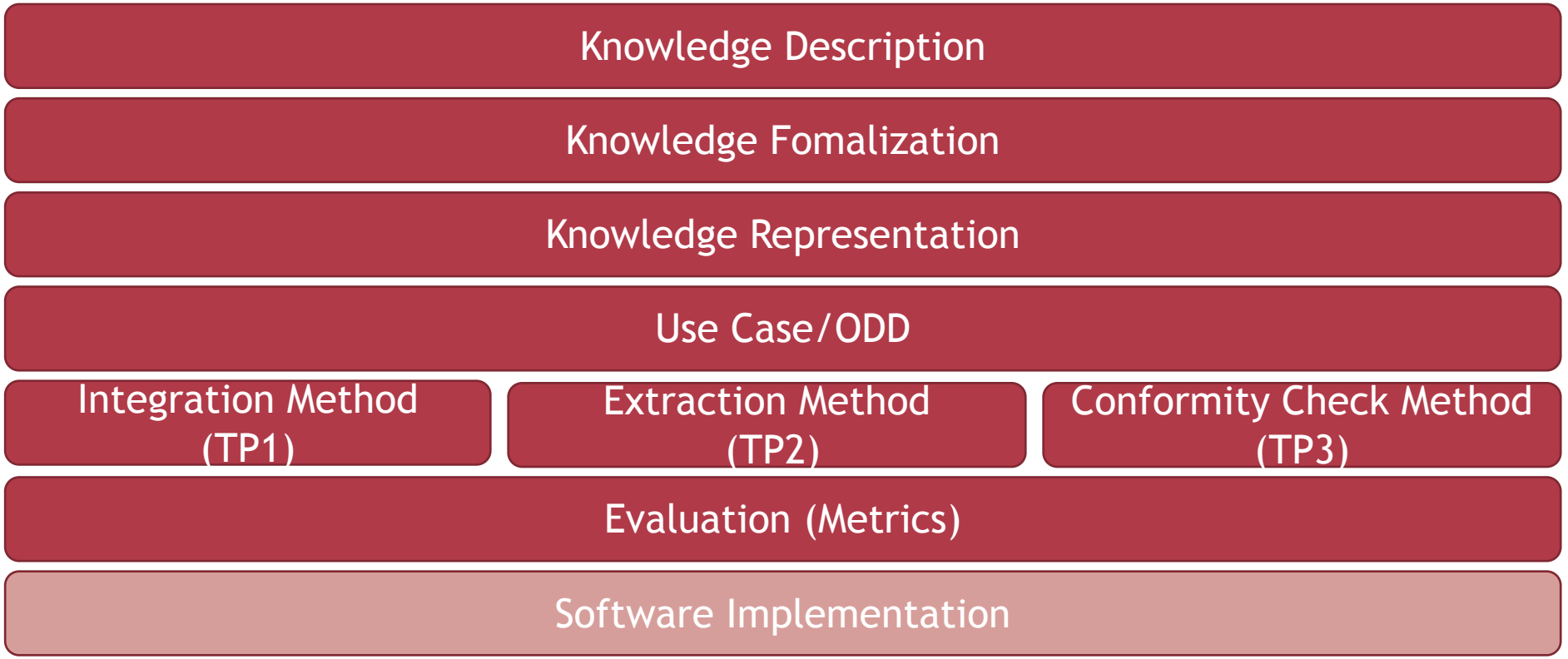
3D Semantic Map



Vehicle Dynamics

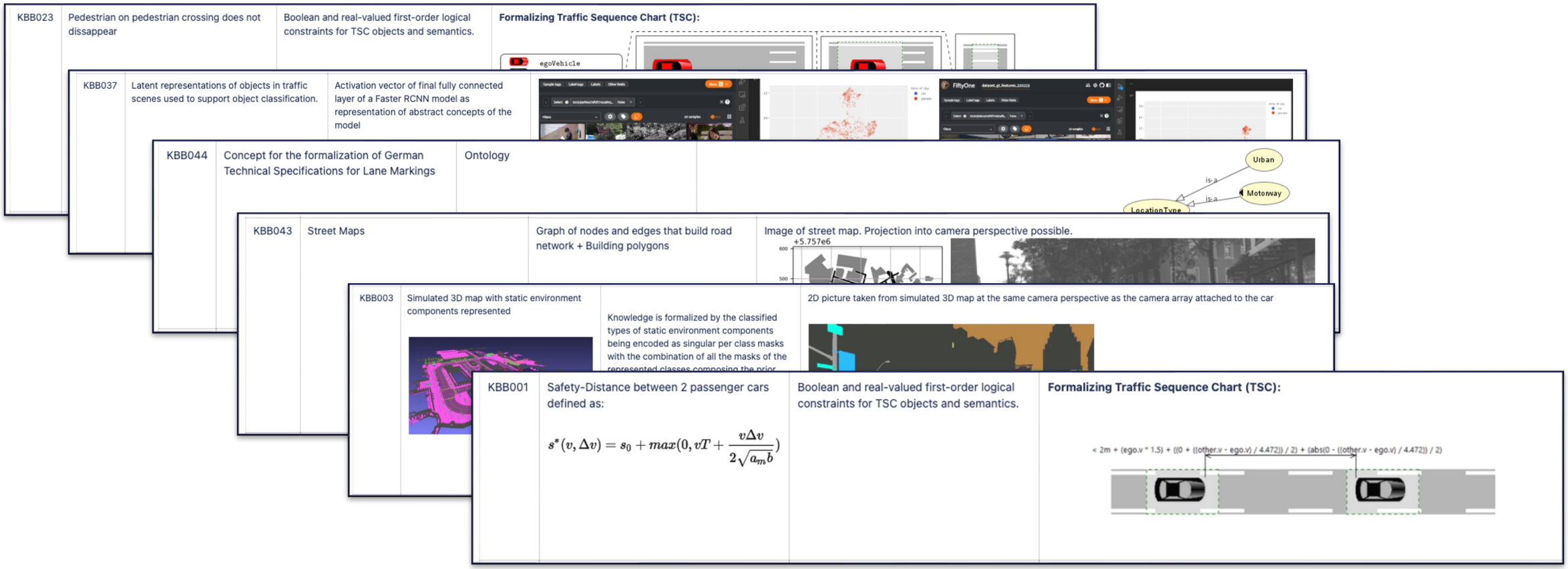
AP1.5 - Knowledge Building Blocks

- Cross-project catalog with related knowledge representations for networking the formalizations from TP1 to TP3
- Content:



AP1.5 - Knowledge Building Blocks

- All project partners have contributed
- A total of 45 different knowledge building blocks in the catalog



3

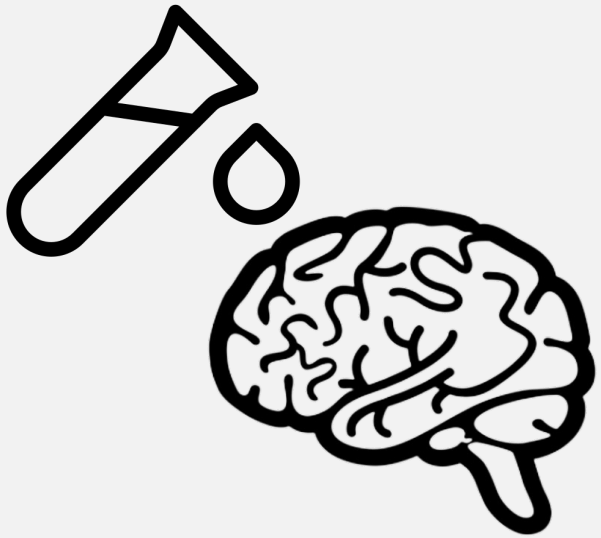
Two Paths to Integrating Knowledge

Knowledge Integration…

into Training of a Learning System

AP 1.1

into Architecture of a Learning System



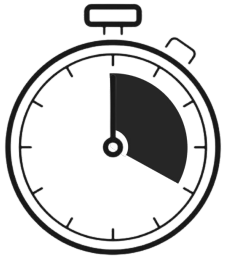
AP 1.2

4

Goals

Generalization with less data and training effort

Robustness of performance and stability



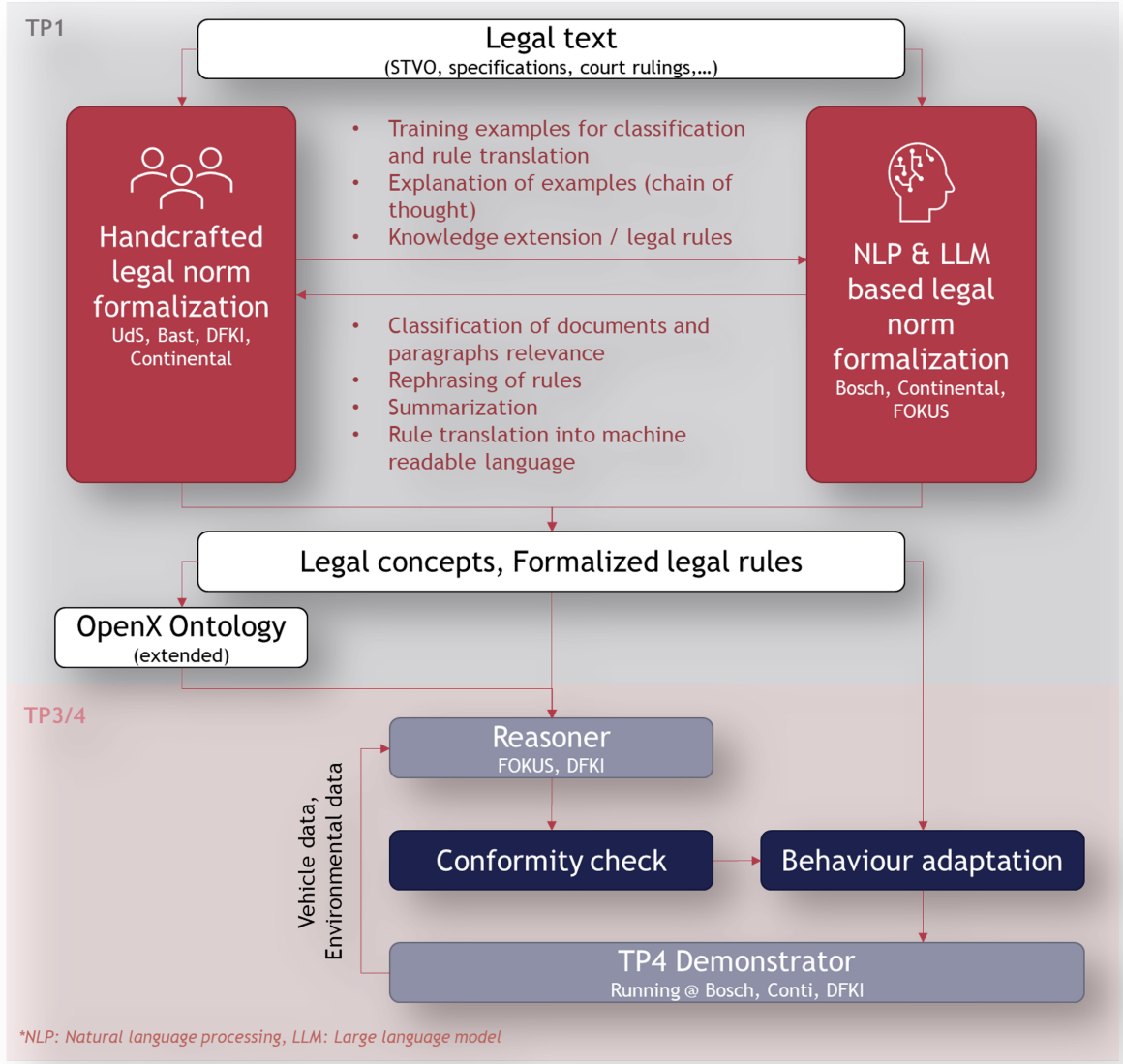
Efficiency in time and data

Transparency & understandable performance

5

Concrete Examples

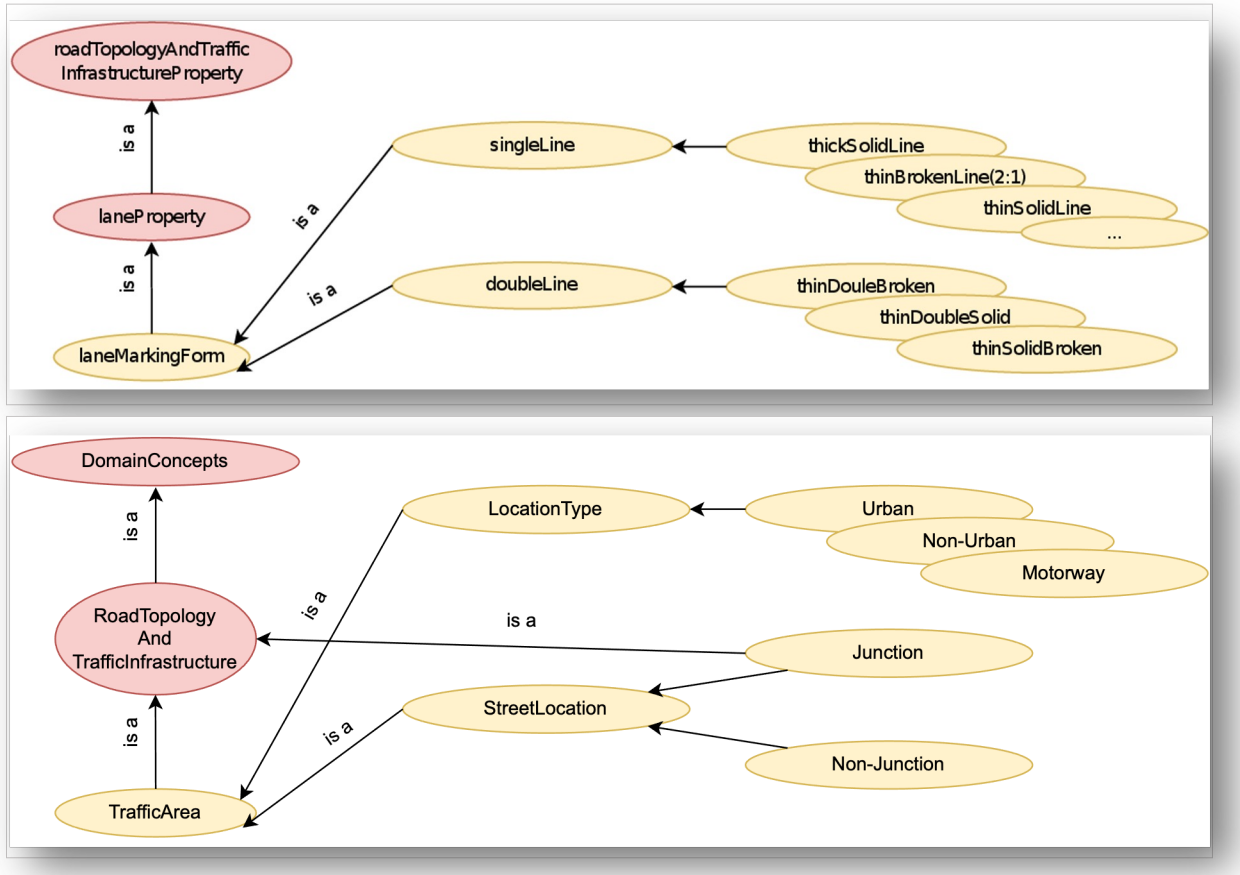
Legal Norm Formalization



BOSCH Invented for life
Continental
UNIVERSITÄT DES SAARLANDES
dfki Deutsches Forschungszentrum für Künstliche Intelligenz German Research Center for Artificial Intelligence
bast Bundesanstalt für Straßenwesen
Fraunhofer FOKUS

3.6	3.7	3.8	3.14	3.19	8
Poster	Poster	Poster	Poster	Poster	Highlight

BASt & Fraunhofer FOKUS - Situation Interpretation

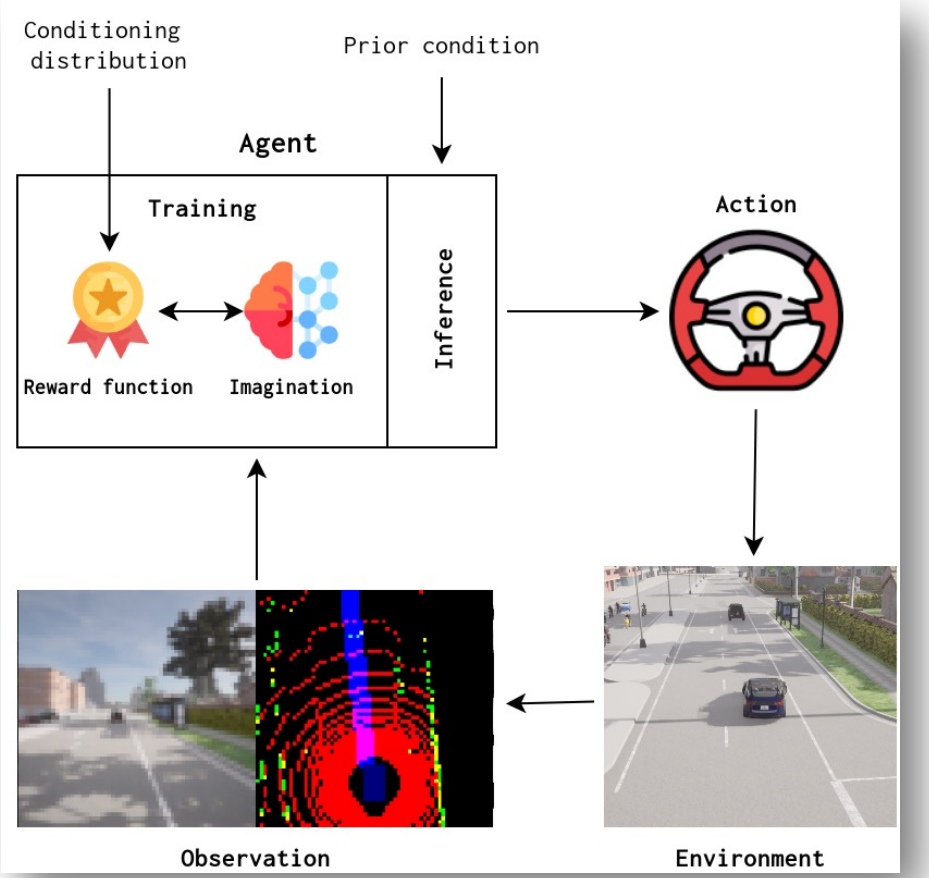


- Improved Situation Interpretation
- Representation via Ontologies
- Hybrid Algorithms of Symbolic Reasoning & Sensor Based Perception

Grabowski, Y. Wang: *A Concept to Support AI Models by using Onologies*, 27th ESV Conference, 2023

3.3
Poster

FZI-MPS & FZI-TKS - Knowledge Informed Reinforcement Learning



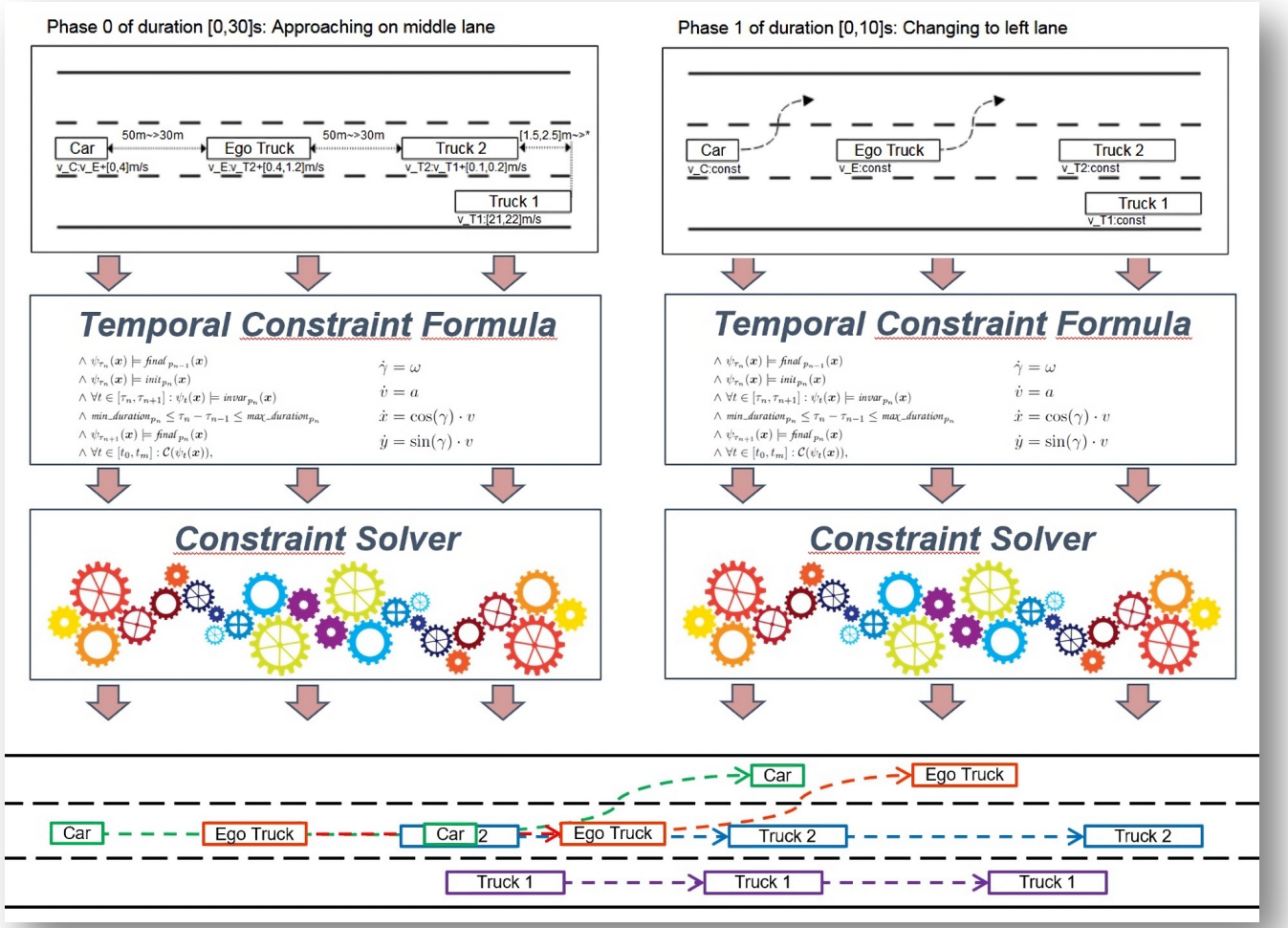
- Transparent Decision Making
- Improved Generalization
- Improved Planning Performance

- Temporal Logic Constraints
- Physical Constraints
- Rules of the Road
- Human Preferences
- Reward Shaping

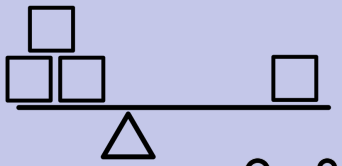
Bogdoll et al.:*Quantification of Actual Road User Behavior on the Basis of Given Traffic Rules*, Intelligent Vehicles Symposium (IV), 2022
Bogdoll et al.: *Informed Reinforcement Learning for Situation-Aware Traffic Rule Exceptions*, International Conference on Robotics and Automation (ICRA), 2024

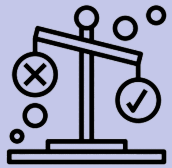
1.12	1.15	2.1	2.12	9	10
Poster	Poster	Poster	Poster	Highlight	Highlight

BTC Embedded Systems: Formalized Traffic Scenarios



- Improved Coverage of Rare but Realistic Test Scenarios

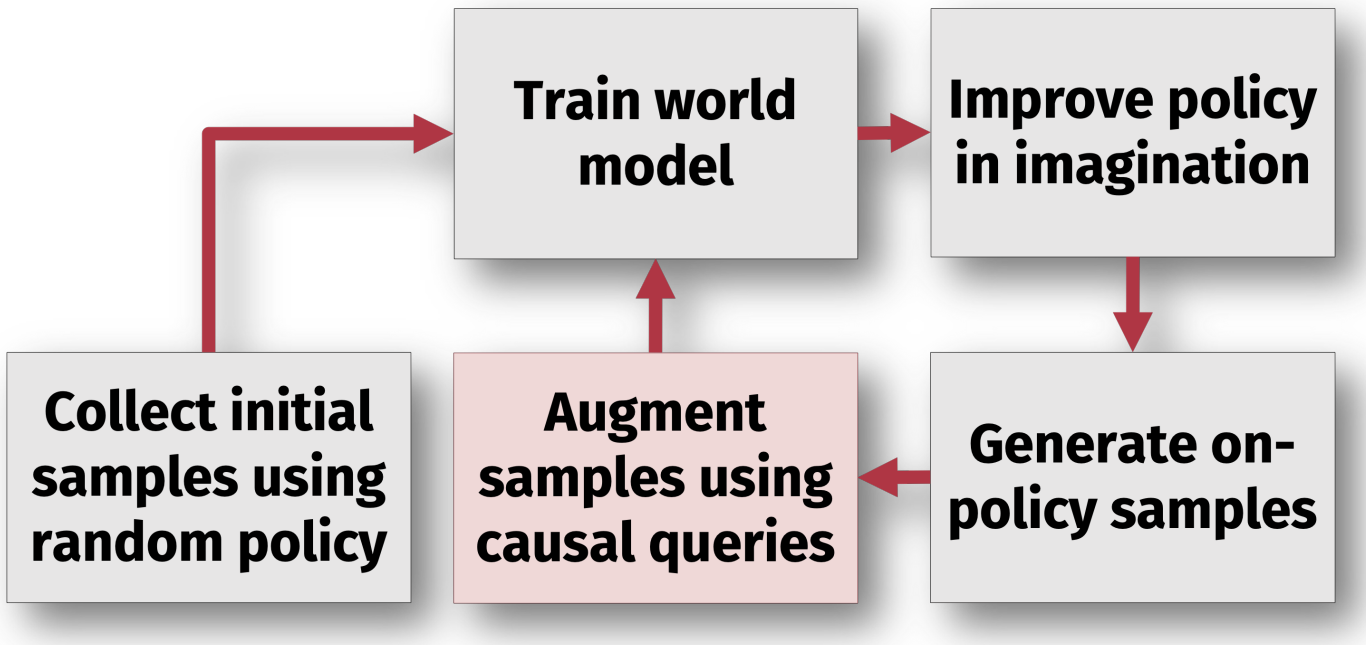




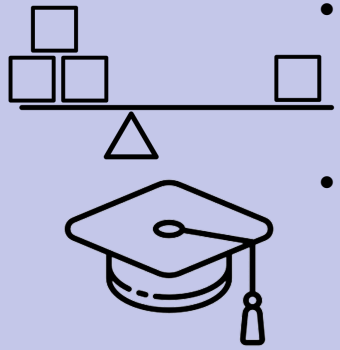
- Logical, Physical & Temporal Constraints
- Formal Traffic Scenario
- Novel Data Pipelines & Simulation Data

1.3
Poster

efs-TechHub GmbH: Causal Models of Vehicle Trajectories



- Improved Robustness to Scenario Variations



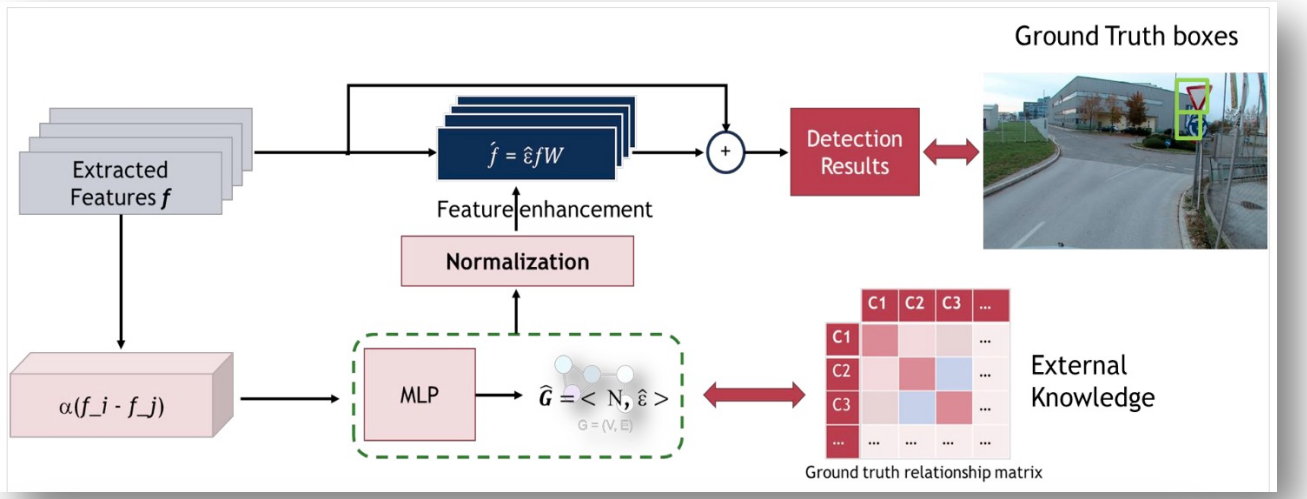
- Causal Relations
- Novel Data Pipelines & Simulation Data

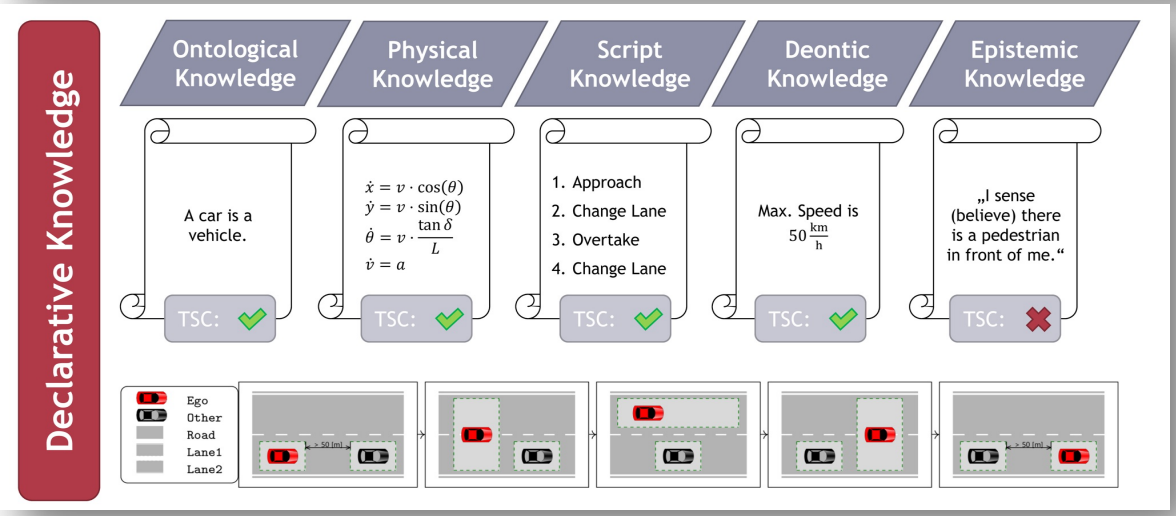
Agarwal, Brunner, Latka, Rudolph: A Causal Model for Physics-Conform Vehicle Trajectories. In IEEE ITSC, 2023.

2.6 Poster

5 Highlight

DLR - Scene Understanding and Situation Interpretation



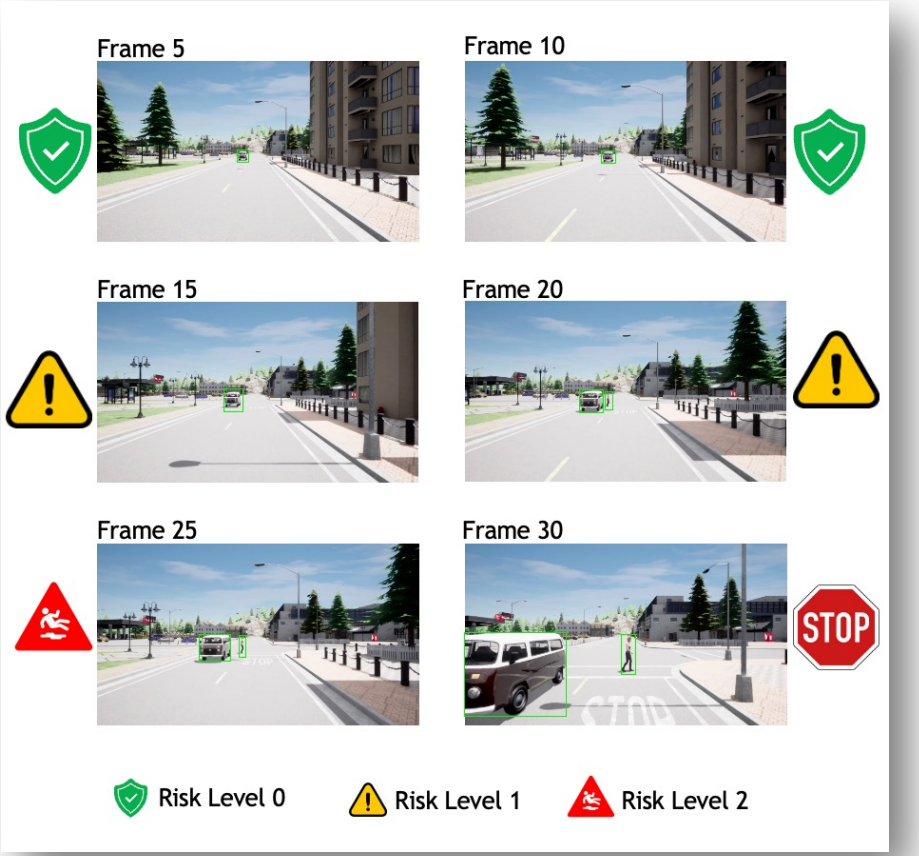


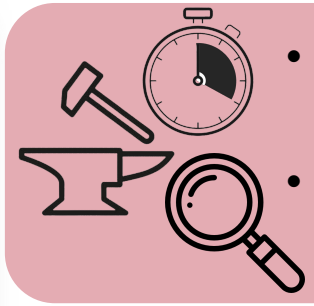
- Improved Tracking & Plausibilization
- Improved Traffic Sign Detection
- Improved Situation Interpretation

- Visibility Constraints
- Co-Occurrence Relations
- Traffic Sequence Charts
- Hybrid Algorithms &
- Novel Architectures

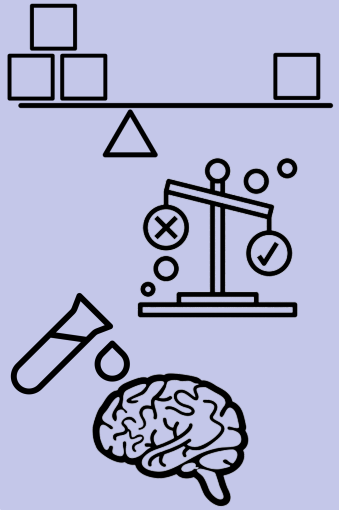
1.16	2.8	3.9	7
Poster	Poster	Poster	Highlight

DFKI – Pedestrian Detection and Risk Assessment





- Improved Pedestrian & Unknown Object Detection
- Improved Risk Assessment & Situation Interpretation

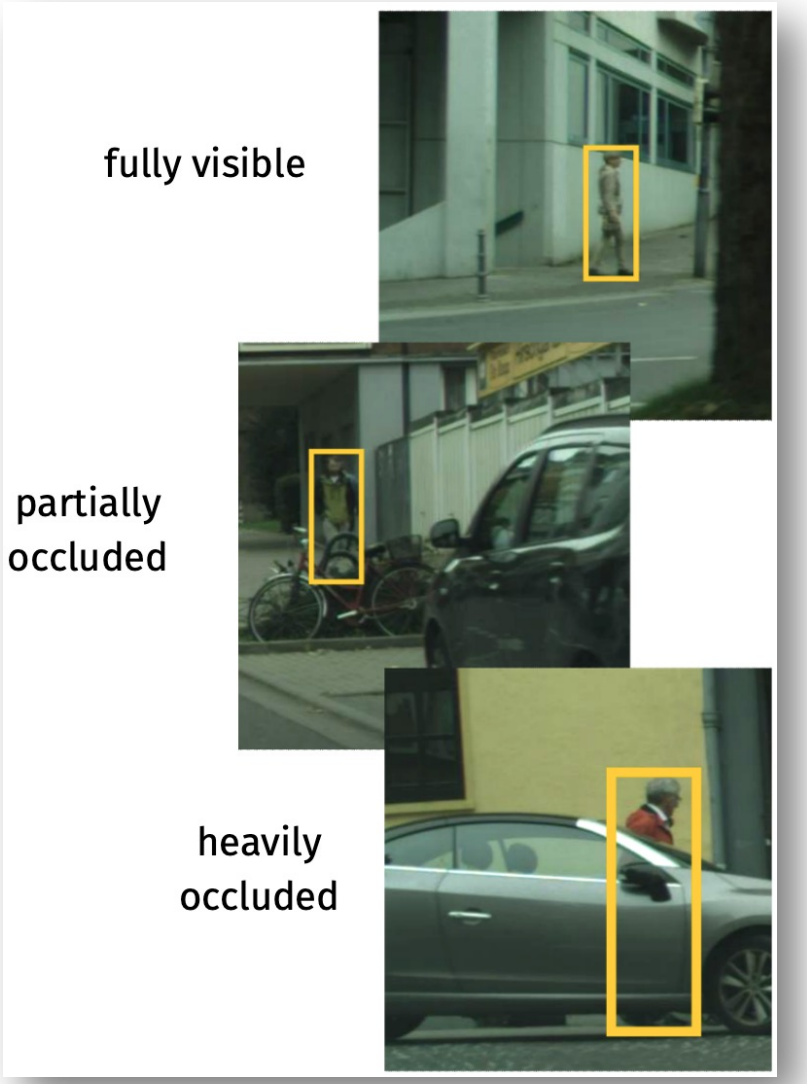


- Prior-Distribution of Pedestrians
- Independent Sensory Inputs
- Symbolic Reasoning over Ontologies
- Hybrid Algorithms & Novel Architectures

Khan et al., *F2DNet: Fast Focal Detection Network for Pedestrian Detection*, ICPR, 2022
Khan et al., Localized Semantic Feature Mixers for Efficient Pedestrian Detection in Autonmous Driving, CVPR 2023

1.7	1.9	1.15	3.10	3
Poster	Poster	Poster	Poster	Highlight

fortiss – Knowledge Guided Occluded Pedestrian Detection



- Improved Pedestrian Detection under Occlusion

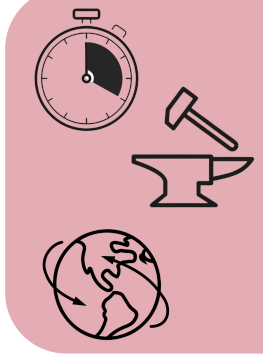
- Semantic Loss Functions

- Meta-Learning Algorithms & Example Reweighing

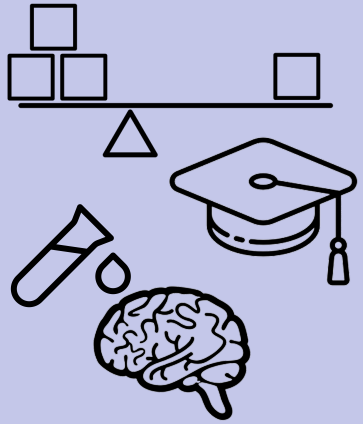
1.6 Poster

4 Highlight

Continental - Scenario Prediction and Control



- Improved Data- & Compute Efficiency
- Improved Generalization of Trajectory prediction
- Improved Planning Performance



- Prior Distributions
- Efficient Trajectory Representation
- Continual Learning Approaches
- Hybrid Algorithms

Yao et al., *F2DNet: An Empirical Bayes Analysis of Object Trajectory Representation Models*, ITSC, 2023
Schlauch et al., Informed Priors for Knowledge Integration in Trajectory Prediction, ECML-PKDD, 2023
Bouzidi et al., Learning-Aided Warmstart of MPC in Uncertain Fast-Changing Traffic, ICRA 2024

2.3	2.4	2.5	2.9	2.11	11+12
Poster	Poster	Poster	Poster	Poster	Highlight

6

Conclusions

Conclusions

- **Knowledge Integration** has delivered desired results.
- It is, however, not a ”Silver-Bullet”
- Its application and results are very context dependent.
- Knowledge Integration is and will remain an integral part of AI development.
- As learning itself, it is a lifelong endeavor.

7

Thank you

Our Team: Impressions from Our Workshops

Thanks to Co-Lead & AP Leads

KI WISSEN

Automotive AI Powered by Knowledge

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KI Wissen 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

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