KI WISSEN
Automotive AI Powered by Knowledge

KI Wissen Final Event | 21-22 March 2024

Knowledge Conformity

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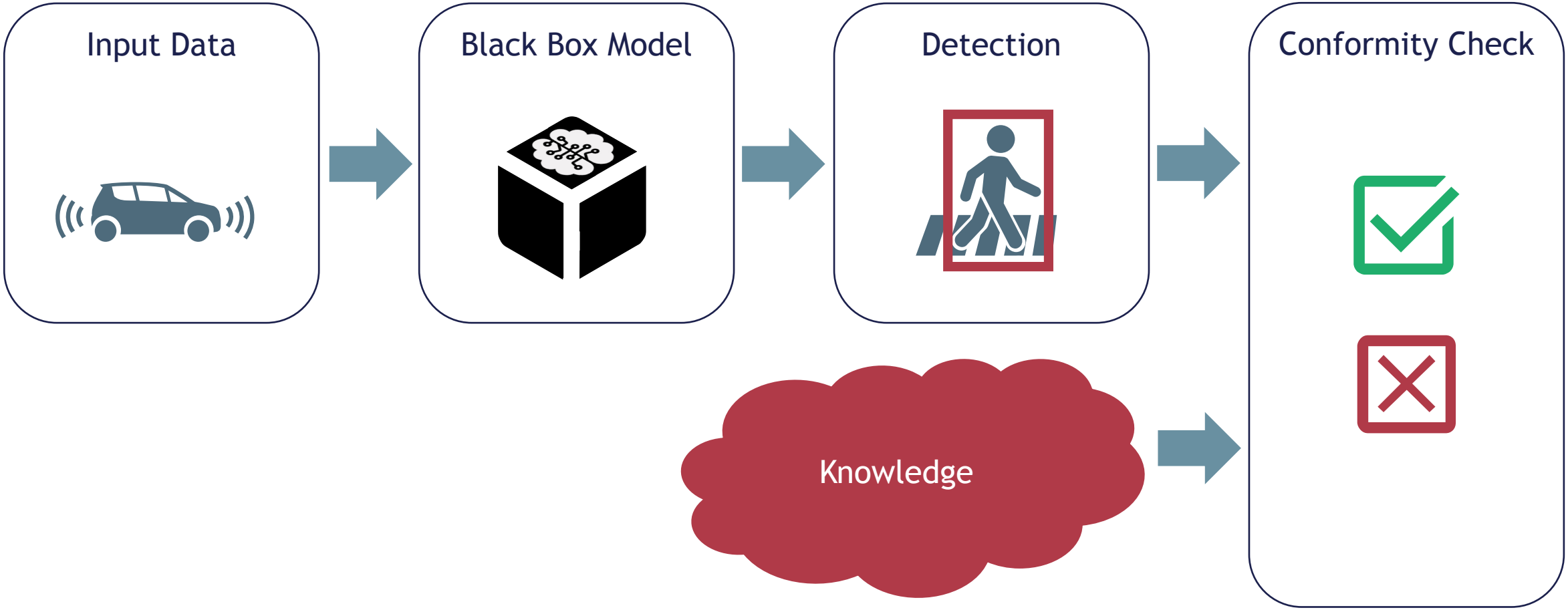
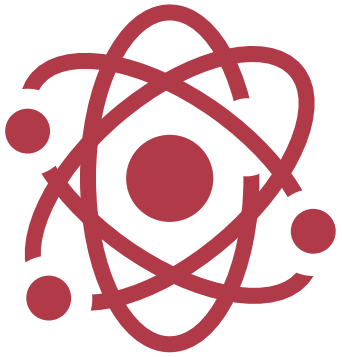
Knowledge Conformity



Knowledge

Scientific Knowledge



- Natural sciences
- Confirmed in experiments
- Formalized in equations

World Knowledge

- Accessible in public knowledge bases
- Formalized in logic rules or knowledge graphs

Expert Knowledge

- Knowledge of specific group
- Challenging to formalize
- Logic rules, probabilisitc relations

Goals

- Detect decisions made by an AI that do not conform to formalized knowledge
- Improve robustness and confidence of AI components
- Plausibility check of the perception
- Plausibility check for development and operation of the AI

With the help of TP2, TP3 allows AI to be tested based on knowledge

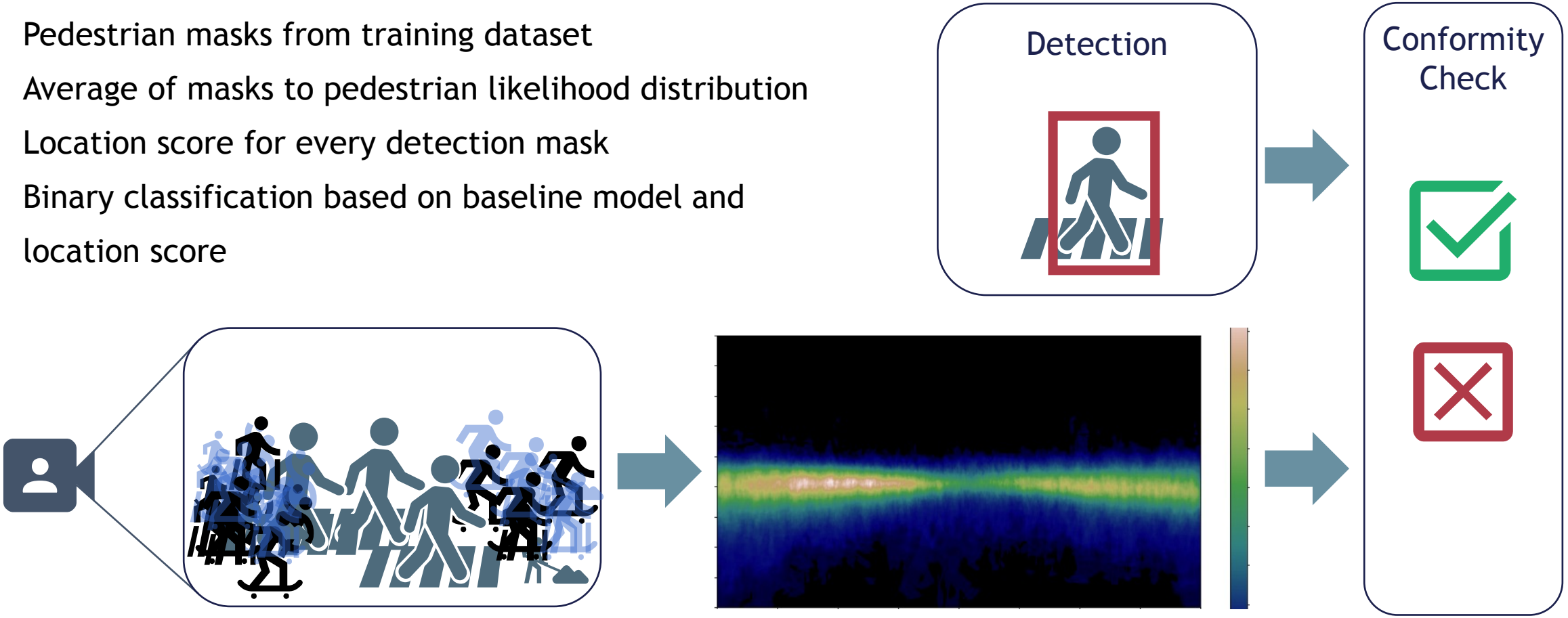
TP3 enables an improvement of the AI development in TP1

Conformity Checks for Pedestrian Detection

Conformity Check for Pedestrian Detection

Pedestrian Likelihood Distribution

- Pedestrian masks from training dataset
- Average of masks to pedestrian likelihood distribution
- Location score for every detection mask
- Binary classification based on baseline model and location score



Conformity Check for Pedestrian Detection

Geospatial Knowledge

- Spatial perspective: Conformity of pedestrian heights
- Street map information: Conformity of pedestrian positions
- Combination: Spatial perspective + street map information

→ Conformity check for every pedestrian detection

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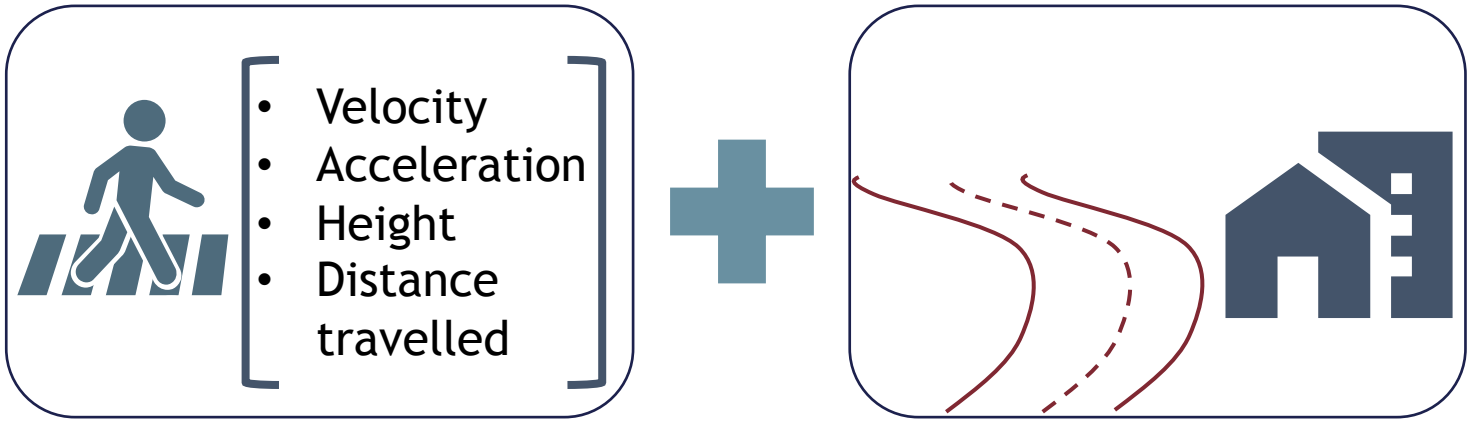
→ Conformity check for every pedestrian detection

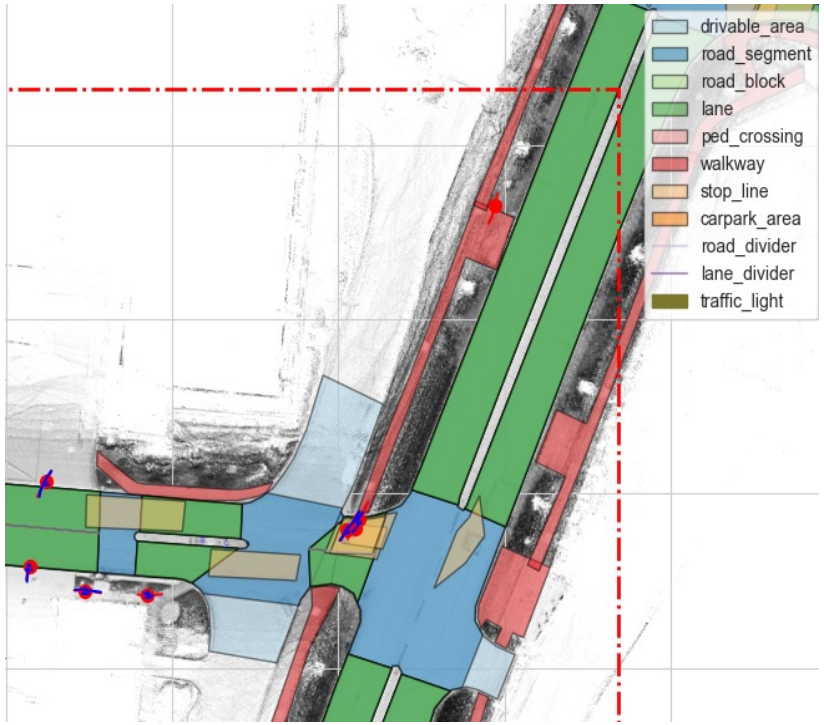
1.8
Poster

Conformity Check for Pedestrian Detection

Map Layer and Pedestrian State Space

- LiDAR-based 3D-detector with Hungarian tracker as baseline
- Pedestrian state space
- Combination with street map layer
- Pedestrian behavior varies with the context
- Logistic regressor for conformity score





1.5
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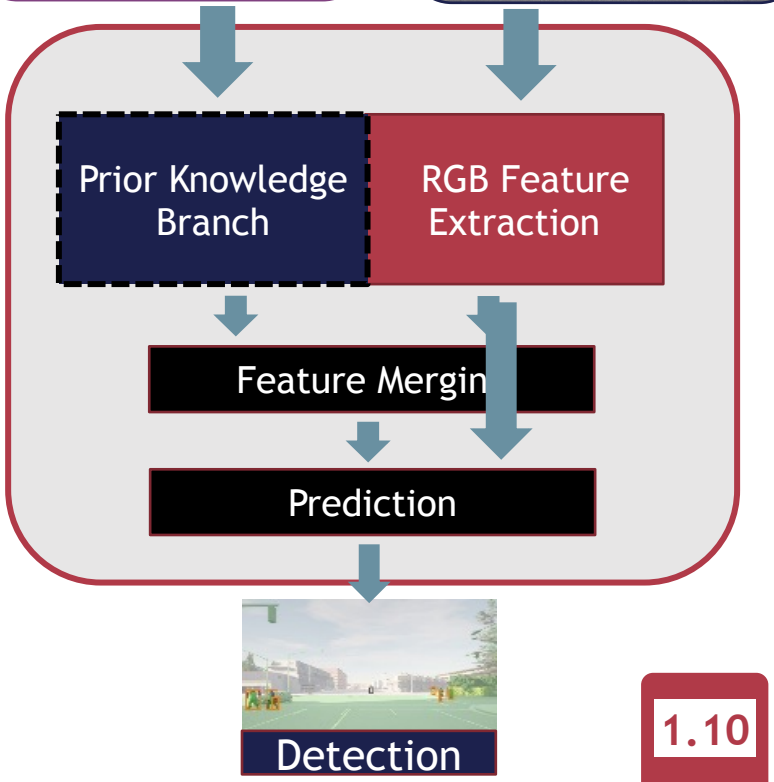
Conformity Check for Pedestrian Detection

Semantic Images

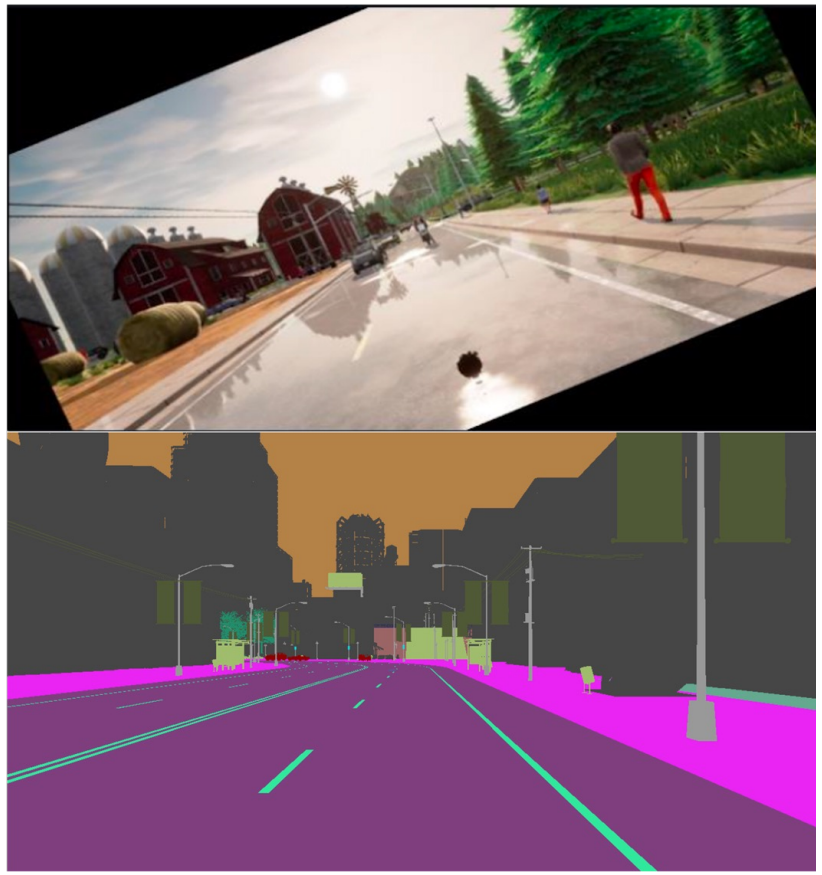
- Baseline: Mask R-CNN
- Knowledge base: 3D static semantic map
- Projection in camera image
- Feature merging
- Filter false positives or detections at unreasonable locations

Prior Knowledge Mask R-CNN

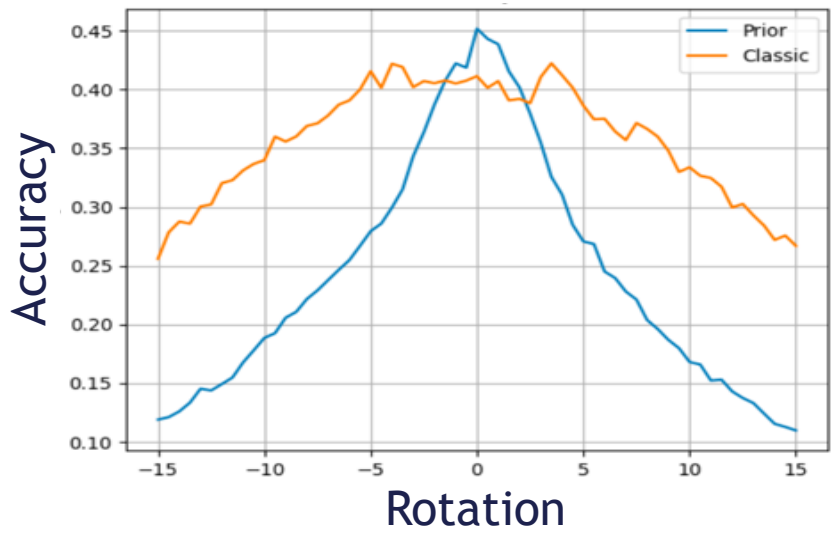


Conformity Check for Pedestrian Detection

Geometric Misalignment of Prior Knowledge



- In reality: prior knowledge not perfectly paired with real world
- Investigate influence of geometrically altered RGB sensor
- Accuracy highly reliable on alignment/calibration



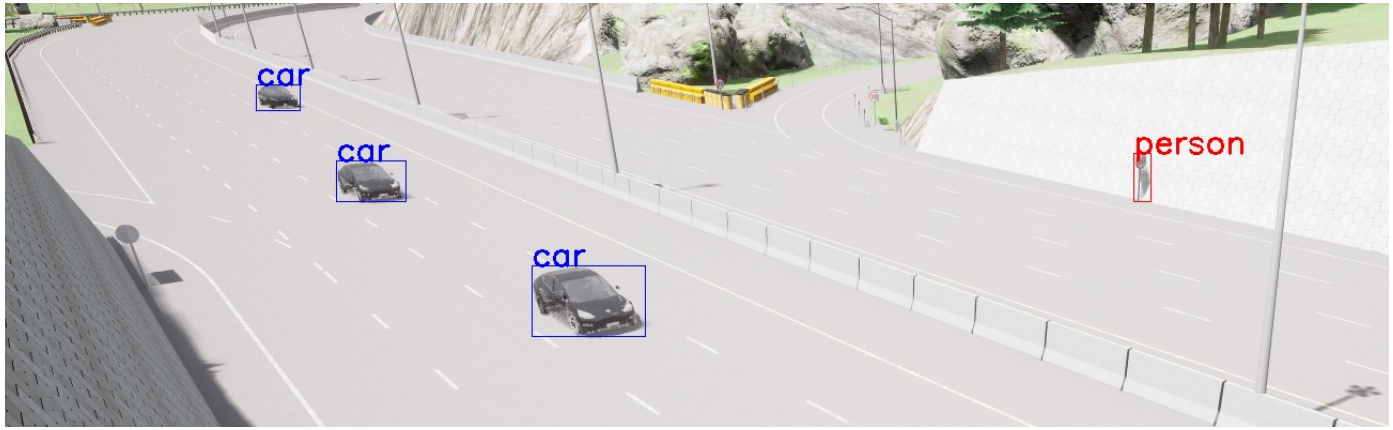
1.11 Poster

2 Highlight

Conformity Check for Pedestrian Detection

Static Scene Knowledge

- Infrastructure camera → static scene
- „Empty“ scene known
- Comparison of predicted bounding box with same cutout in empty image
- Determination of similarity using structural similarity index (SSIM)
- Classification in true or false positive via threshold

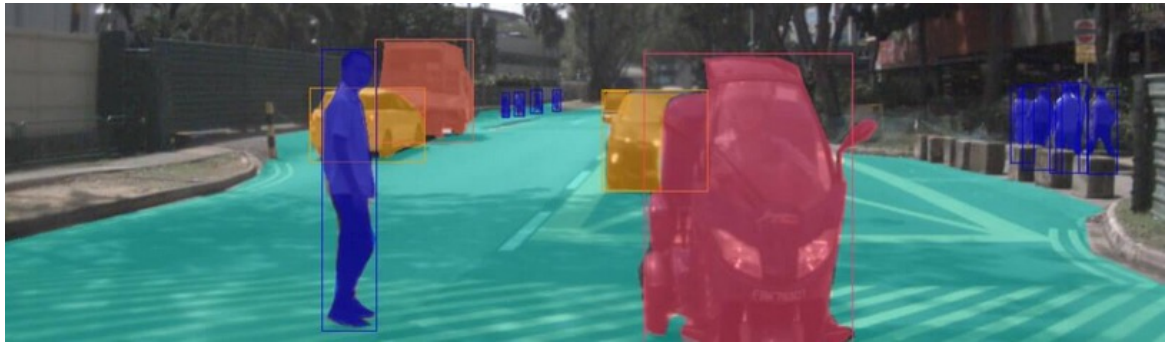


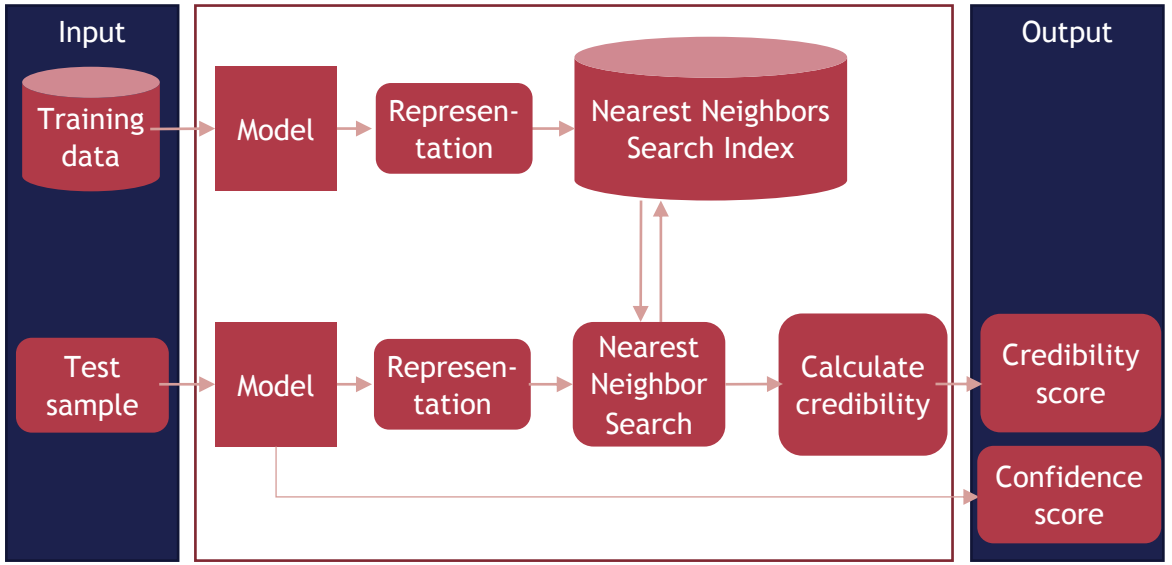
1.4
Poster

Conformity Check for Pedestrian Detection

Network Internal Pedestrian Representation

- Knowledge: Network internal representation of training data
- Comparison of internal representations
- Credibility and confidence score
- Outcome: Cross-validation improves confidence in neural network predictions

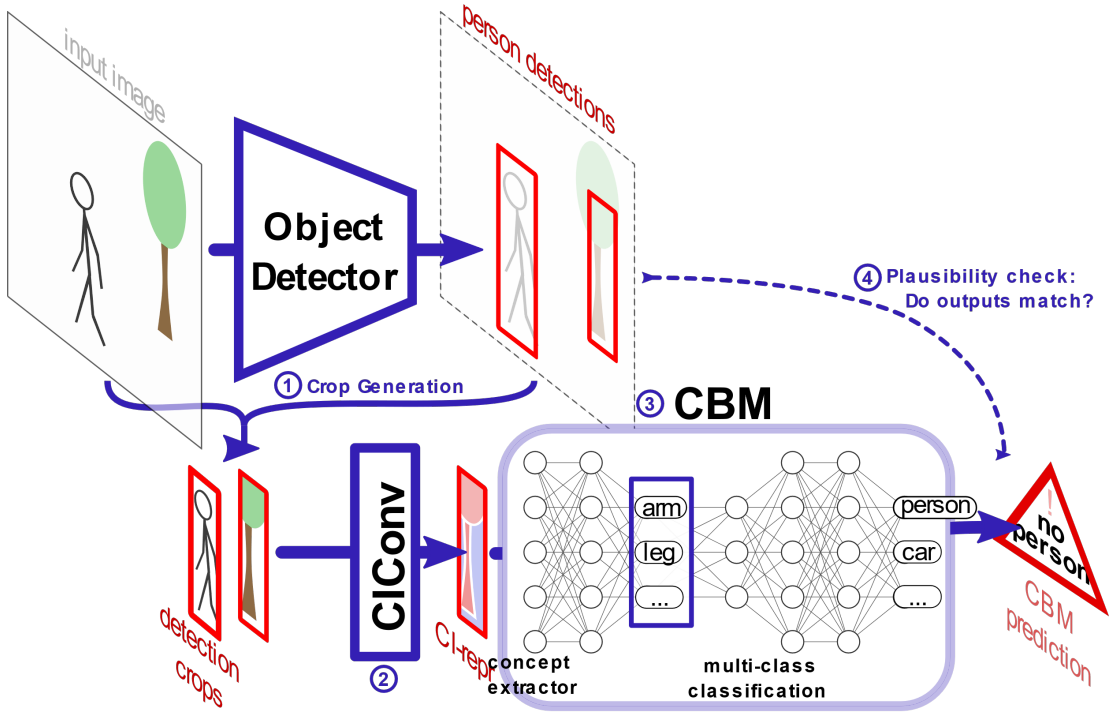




Conformity Check for Pedestrian Detection

Concept Bottleneck Model (CBM)

- Small, interpretable model that verifies detections
- Detection of object/body parts (arms, legs)
- CBM detects hallucinated objects and reduces false positives
- Potential for reliable error monitoring in safety-critical applications



1 Highlight

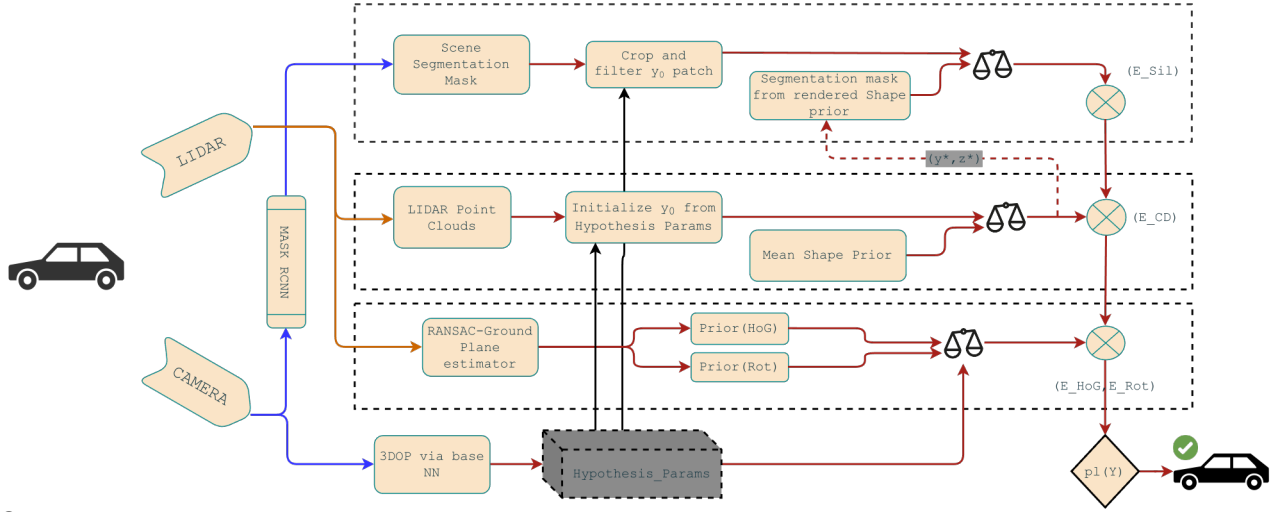
Conformity Check for Object Detection

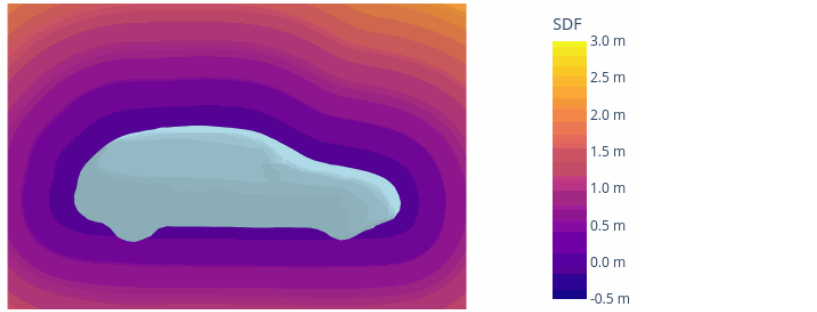
Energy-Based Models

- Cross sensor (LiDAR and camera)
- Four energy functions informed by prior knowledge

Key Components:

- Chamfer distance energy function
- Silhouette/differential IoU energy function
- Height and rotation energy function





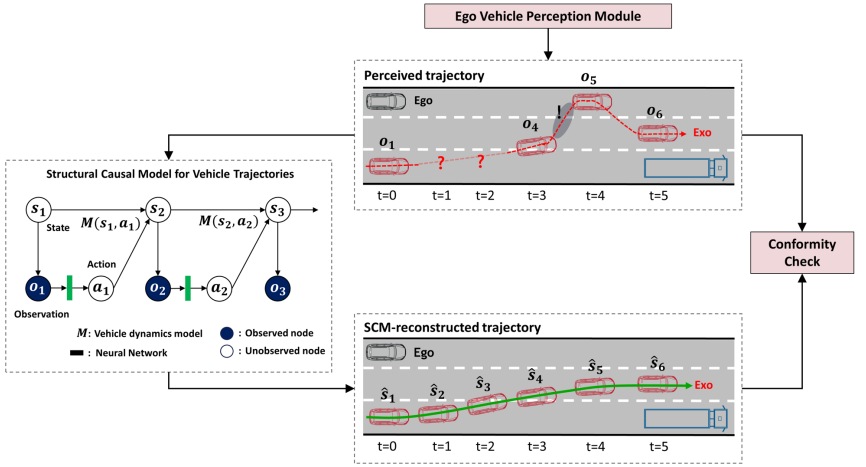
1.12 Poster

Conformity Checks for Complex Lane Changes

Conformity Checks
Complex Lane Changes

A Causal Model of Vehicle Trajectories for Integration of a Priori Knowledge

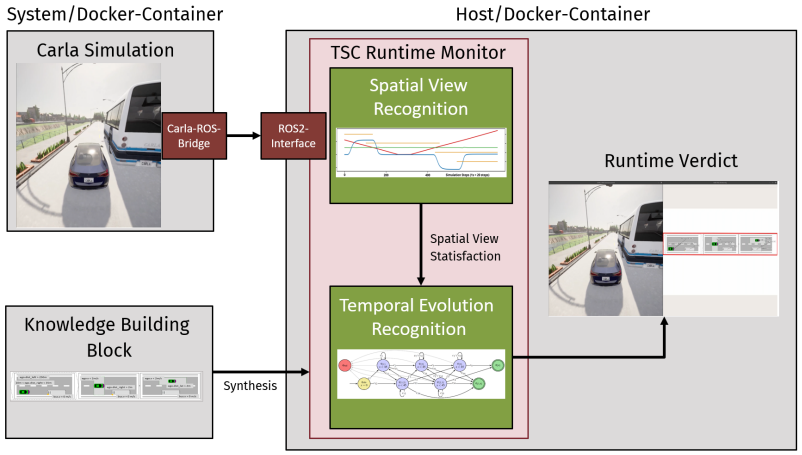
- Detection of physically unreasonable trajectories
- Structural Causal Model (SCM)



5 Highlight

Knowledge Formalization, Integration & Monitoring with Traffic Sequence Charts

- AI driving function
- Continuous runtime monitoring for checking conformance with multi-stakeholder knowledge

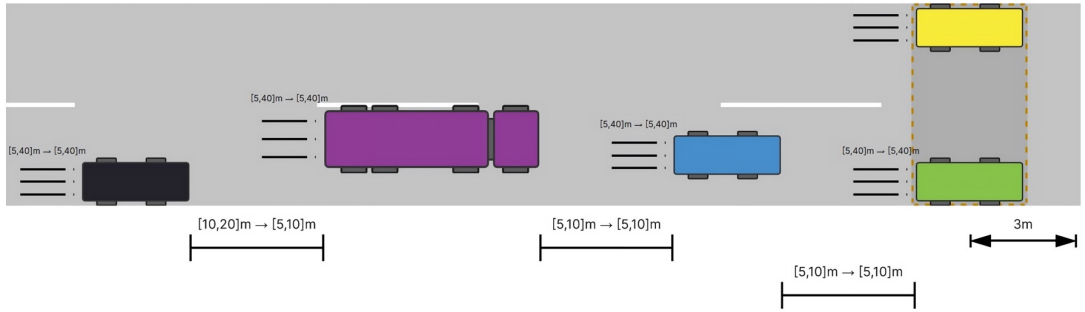


7 Highlight

Conformity Checks
Complex Lane Changes

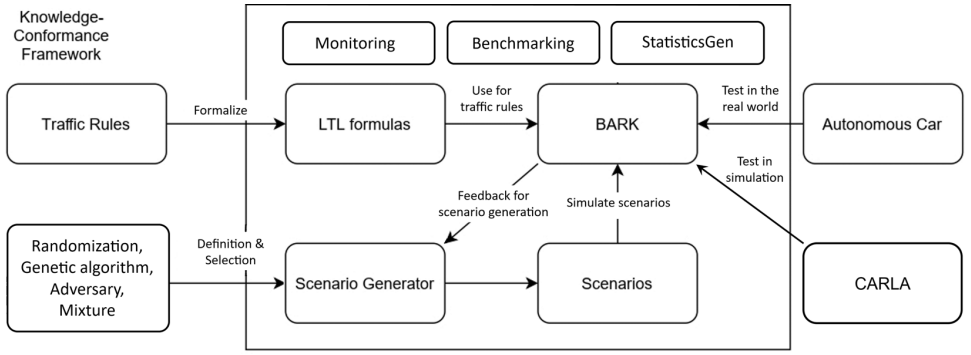
Generating monitors from formalized scenarios

- Formal Traffic Scenarios (FTS)
- Conformity check with generated monitors



Monitoring Traffic Rule Conformance and Integrated Knowledge Impact

- Quantifying traffic rule conformity
- Signal Temporal Logic (STL)



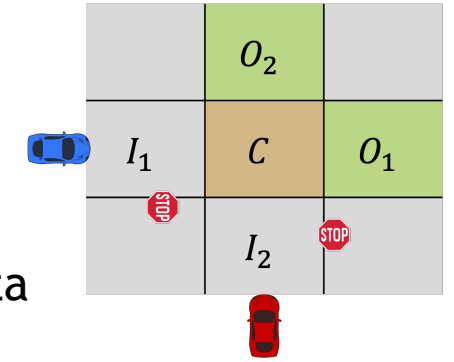
3.11
Poster

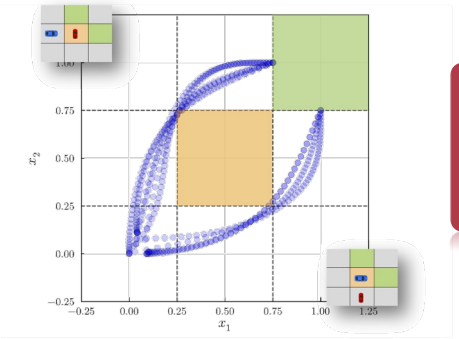
Conformity Checks for Motion Planning

Conformity Checks
Motion Planning

Motion Planning under Temporal Logic Specifications

- Model and control vehicle motion at urban intersections
- Convert the temporal logic rules to Büchi automata



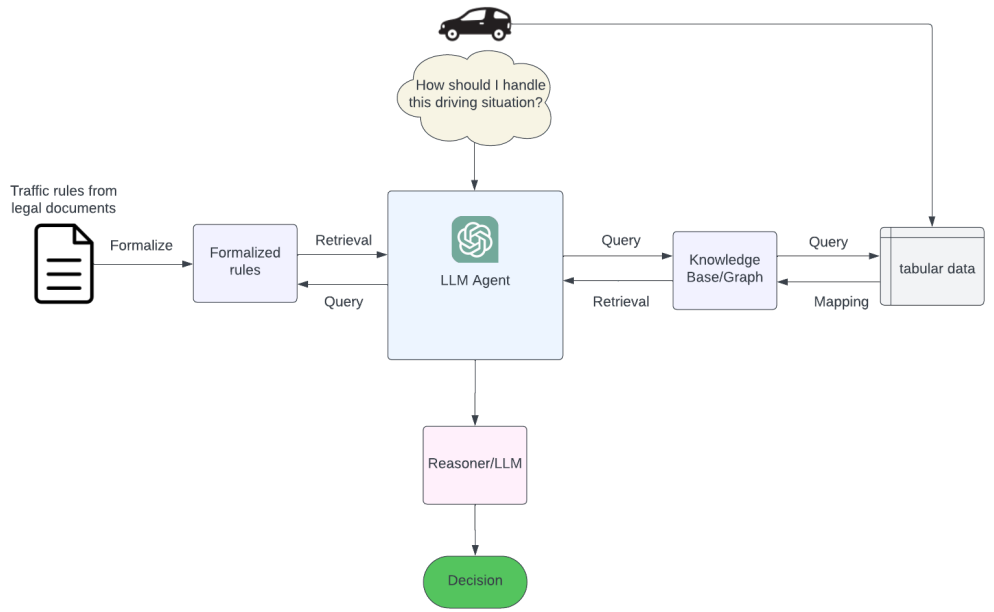


2.10 Poster

9 Highlight

Harnessing Symbolic Knowledge Extraction and Utilization for informed Decision-Making

- LLM agent assisted reasoning for rule compliant decision making
- Integration of symbolic systems for conformity check

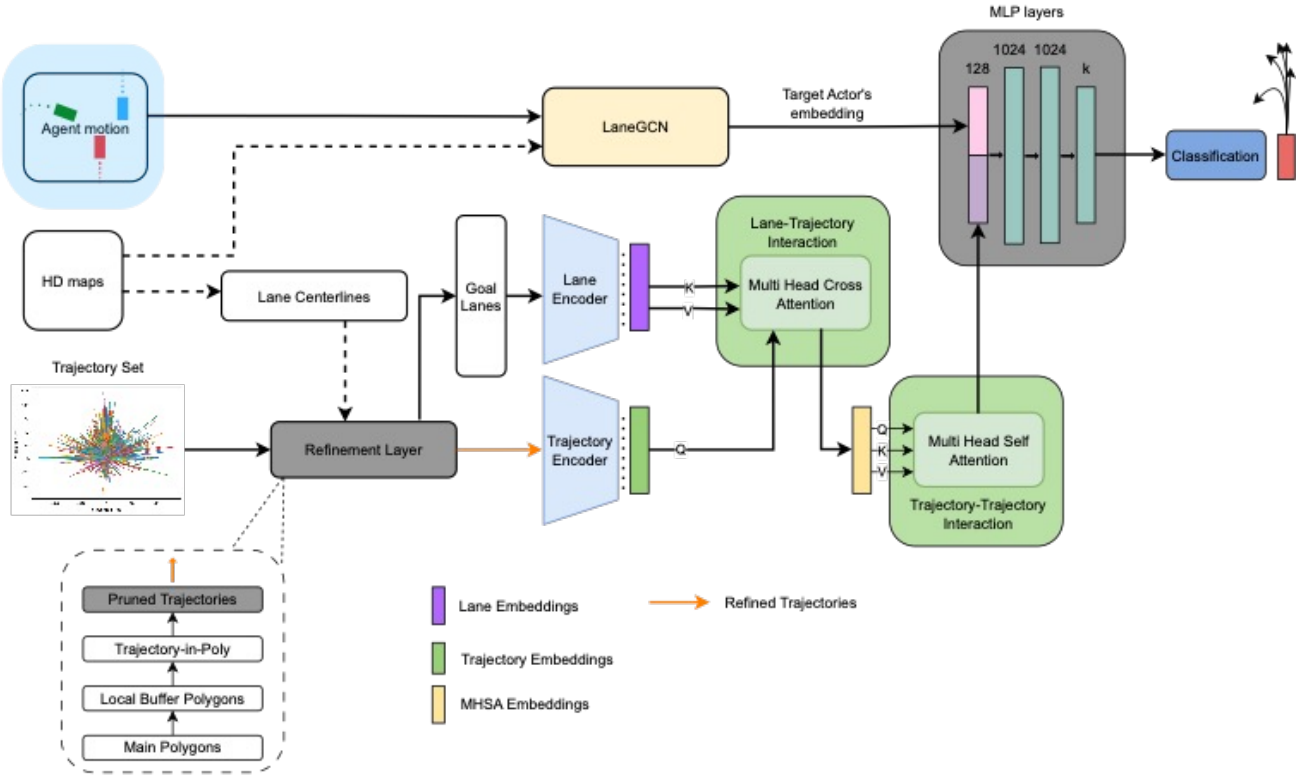


3.1 Poster

Conformity Checks
Motion Planning

Knowledge Integrated Plausible Motion Forecasting (KI-PMF)

- Predict trajectories compliant with the environment and vehicle kinematics
- Classification of trajectories



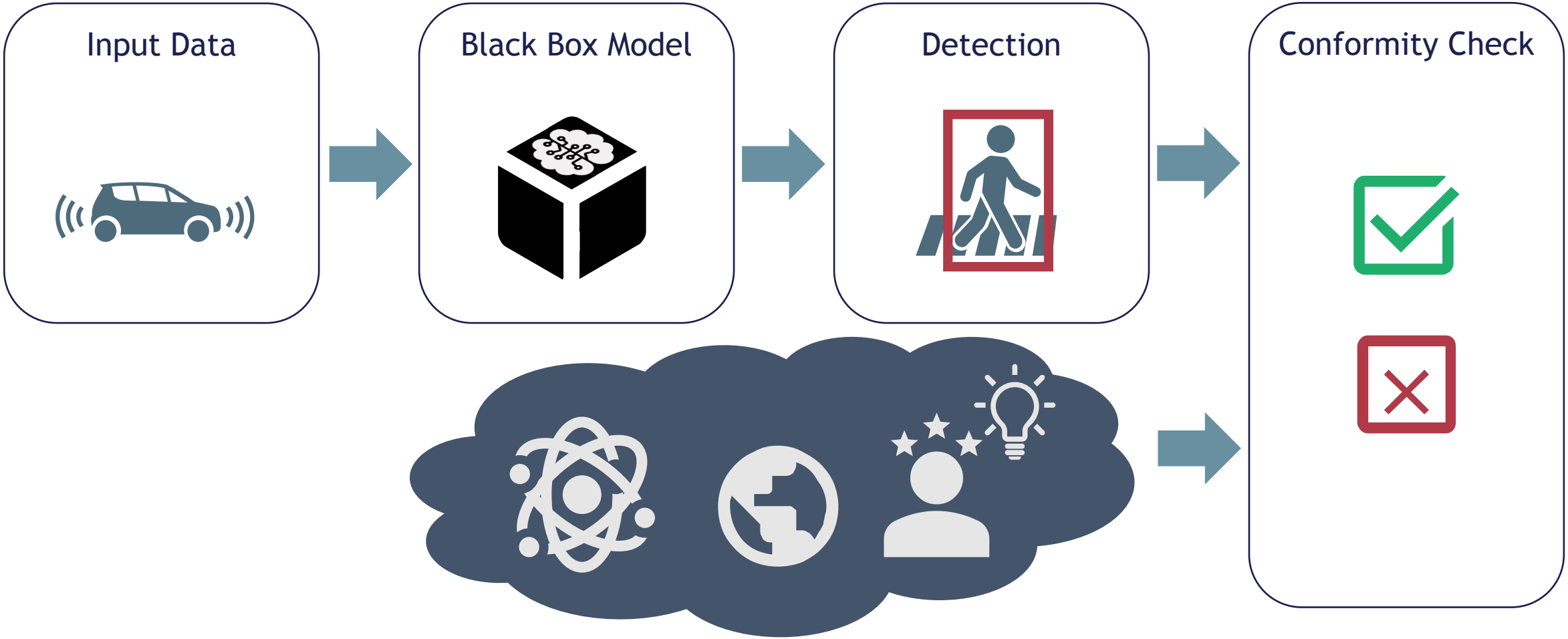
2.2 Poster

10 Highlight

TP3
Activities

- F2F workshops
- Topical workshops

Conclusion



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Thank you for your attention!

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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

VDA LEITINITIATIVE

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