COPE – Collective Perception for the avoidance of collisions and dangers of VRUs with C-ITS

Dr. Andreas Kuhn
ANDATA

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ACI MOBILITY SUMMIT
AUTOMATION CONNECTIVITY INFRASTRUCTURE MOBILITY

Project COPE

Title	Time
COPE	2021/22
Funding	
FFG Forschung wirkt. — Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie	
Consortium	
University of Applied Sciences Upper Austria, ANDATA, Logistikum, HiTec marketing, Joanneum Research, swarco	
Content	
• Collision avoidance VRU with C-ITS and Collective Perception	

- Reduction of accidents with vulnerable road users
- by avoidance of collisions and dangerous situations (informing/warning/braking/evasion)
- with the help of car2X communication (ITS-G5)
  - by sharing one's observation
  - by sharing the own intention
  - by local context information
  - Collective Perception
- Partners

KTM, MAN, Car 2 Car Communication Consortium, C-ROADS, Land Salzburg, ÖAMTC, TESTREGION DigiTrans, Stadt Hallein, COPE, ACI Mobility Summit (Automation, Connectivity, Infrastructure, Mobility)

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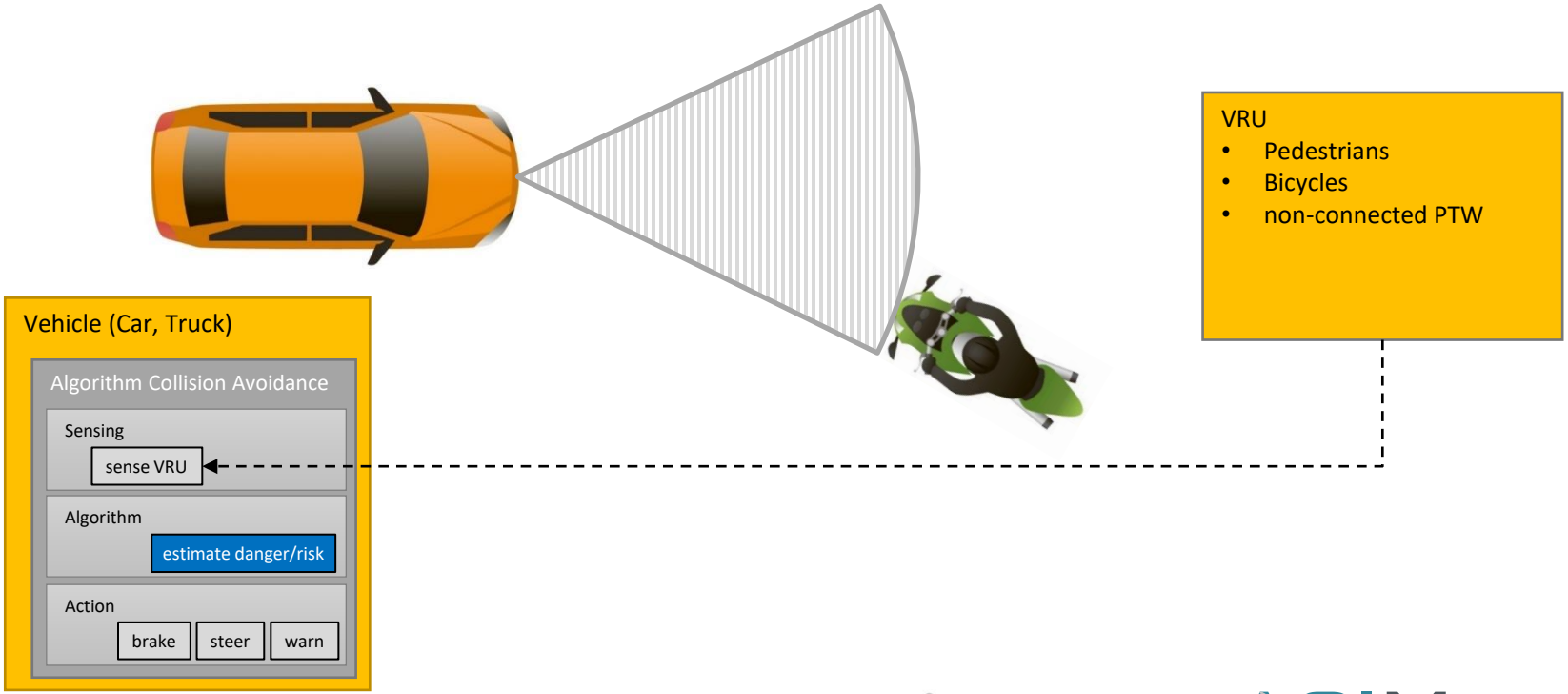
System Architecture: Autonomous Emergency Brake & Warning for Collision Avoidance with VRU



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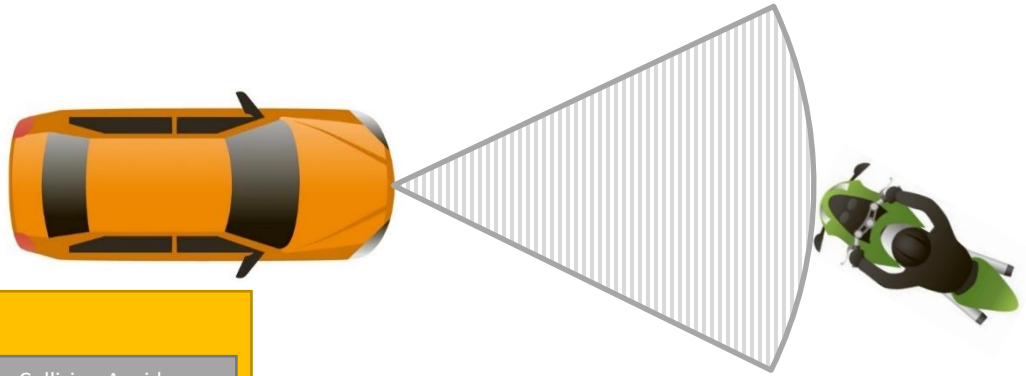
System Architecture: Autonomous Emergency Brake & Warning for Collision Avoidance with “Smart VRU”



Vehicle

Algorithm Collision Avoidance

Sensing

sense VRU | get Intention

Algorithm

map | estimate danger/risk

Action

brake | steer | warn

VRU (“smart” incl. PTW)

Algorithm Collision Avoidance

Sensing

sense motion

Algorithm

estimate intention | map

Action

warn | share intention

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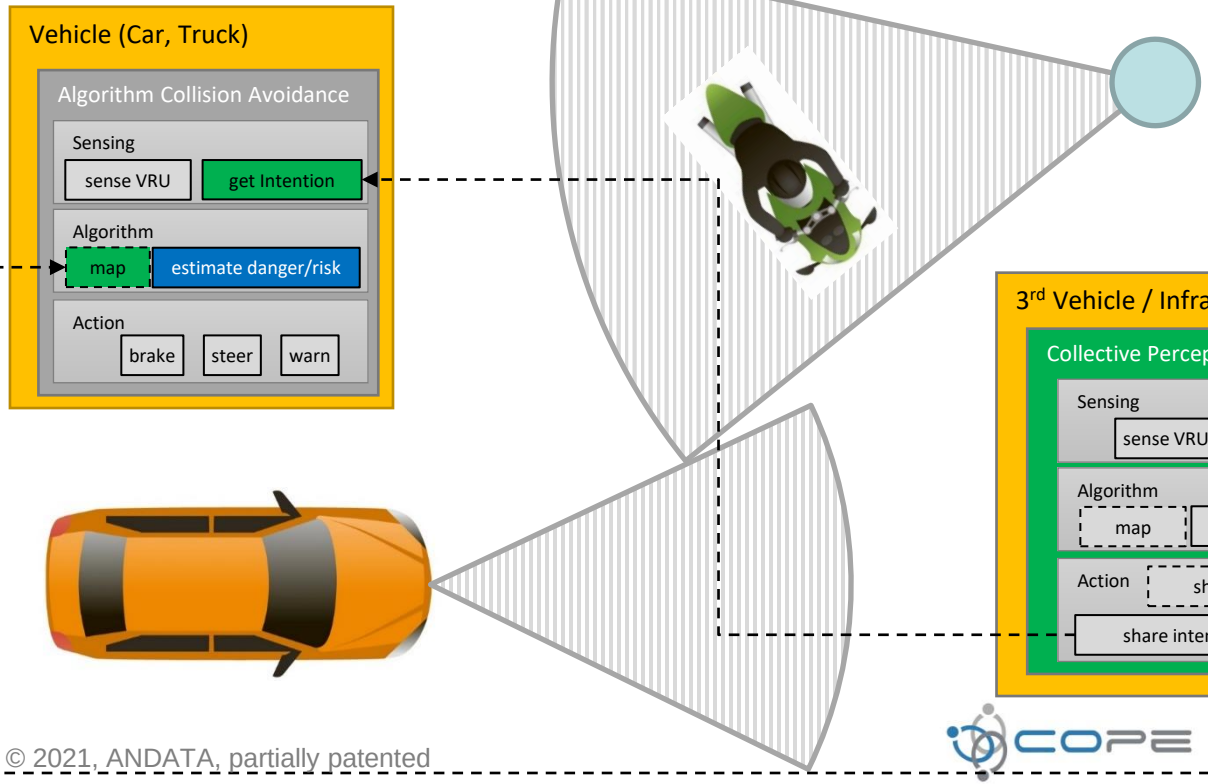
System Architecture: Autonomous Emergency Brake & Warning for Collision Avoidance with Infrastructure



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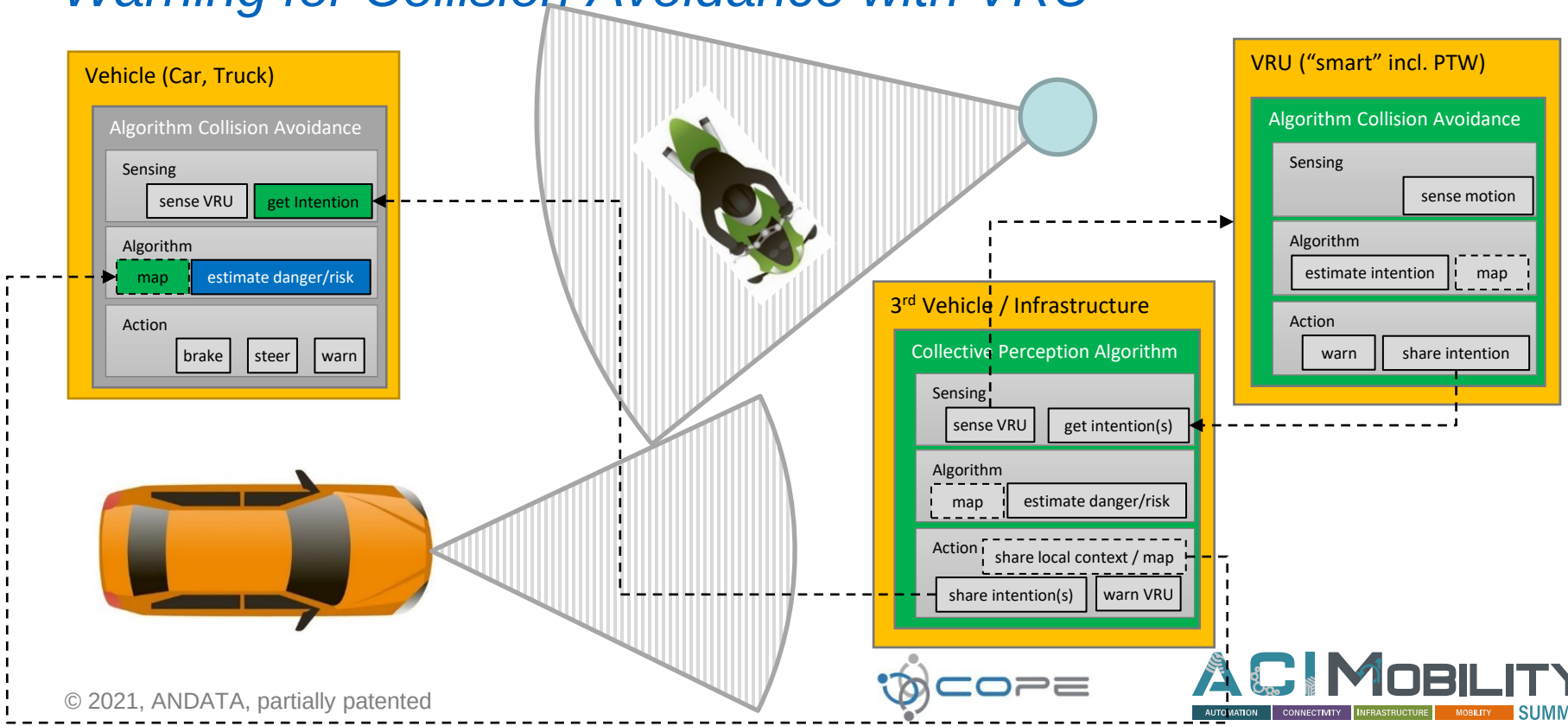
System Architecture: Autonomous Emergency Brake & Warning for Collision Avoidance with VRU



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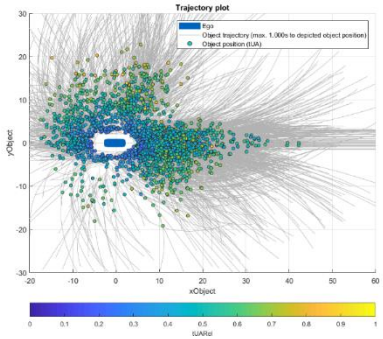
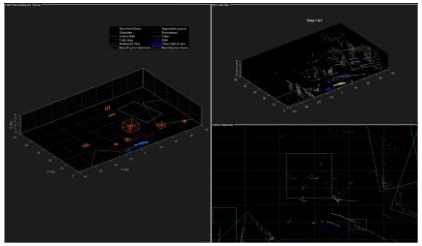
COPE System-of-Systems Components





Connected
Autonomous Emergency Brake- & warning systems for collision avoidance

C-ITS Connectivity Vehicles & Infrastructur & VRUs

Traffic sensors for detection of all traffic participants incl. VRUs (Pedestrians, (P)TWs)

uHD maps for environmental & context models

Collective Perception

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Challenges Functional Development

- Definition of according actions and timing
- Minimization of false classifications to assure user acceptance
- Complexity of interaction mechanisms
- Formulation of intentions and observations
  - for clear interpretability by the others
  - universality and independence from type of vehicle/traffic participant
- Merging/combining information with different confidence
- Formulation/specification of messages within C-ITS services types (MAP, DEMN, CPM, IVI,…)
- …

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Consequences & Solution Strategy & Methods

Integral Development Process

Top-down vs. bottom-up

- Strictly requirements driven
- Clear and comprehensive specification of the desired behaviour

Probabilistic View

- Bayesian approaches
- Robust control must be able to cope with stochastics
- Robustness management

Effectiveness Rating

- #1 validation method
- Identification & quantification of critical components

Data driven development

- Scenario based approach
- Stochastic simulations for development & validation
- Sensor & behavioural data from real observations

AI & Machine Learning

- Systematic management of data and scenarios (analytics)
- Excellent functionality
- Handling complexity

Functional Architecture

- Clear & transparent design & functionality (no blackboxes)
- Clear & explicit Operational Design Domains

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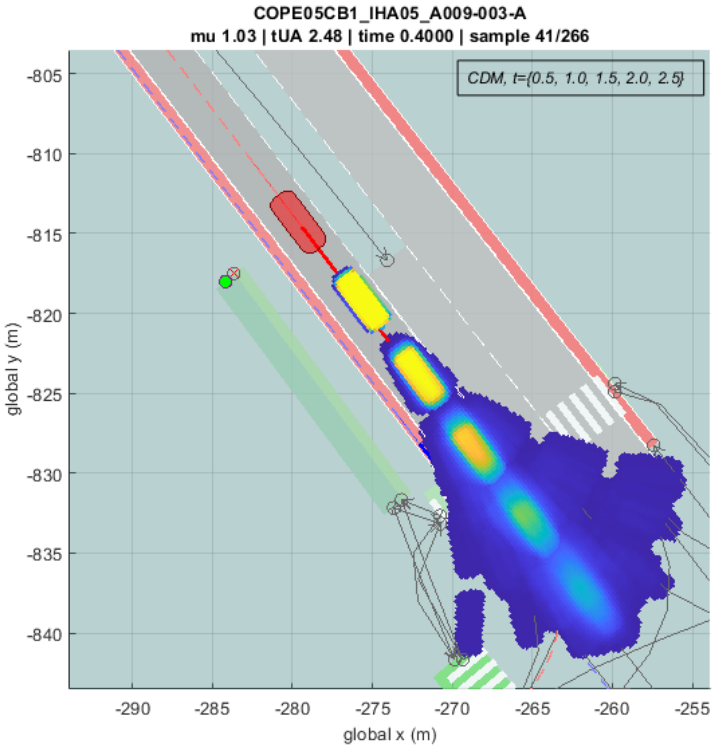
Calculation/Estimation Conditional Probability of Positions

- Probabilities of positions
- conditionally (>Bayes)
- dependent on
  - driver constitutions
  - vehicle capabilities
  - road configuration & conditions
  - environmental context
  - actuators
  - …

➢ Stochastic driver & vehicle models



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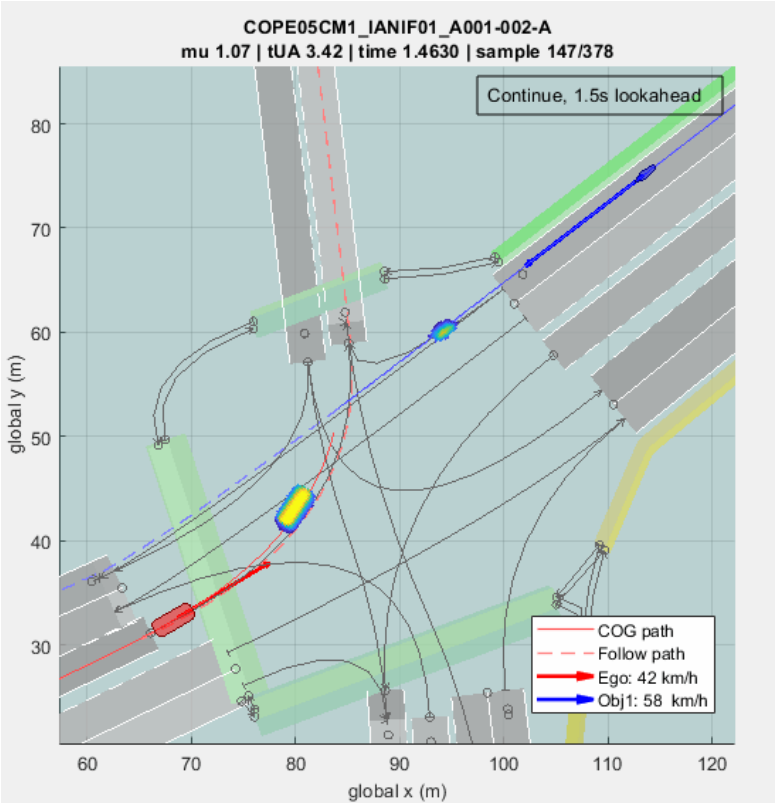
Calculation of Collision Probabilities & Severities



- Generating Scenarios with potential collisions
- Evaluation and rating of alternative actions
- Retrieving required actions

➢ Automated specification of actions

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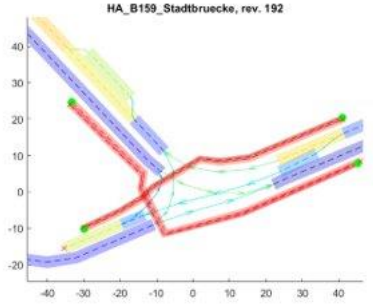
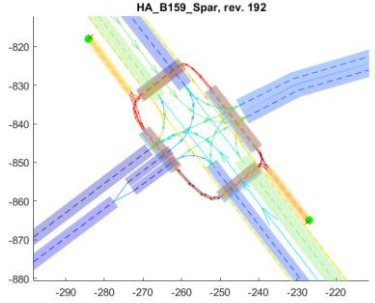
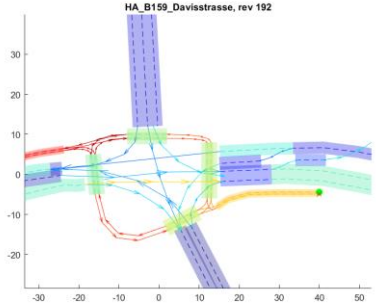
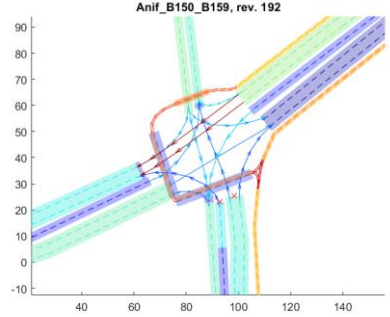
Scenario-Generation Hallein/Salzburg & further…









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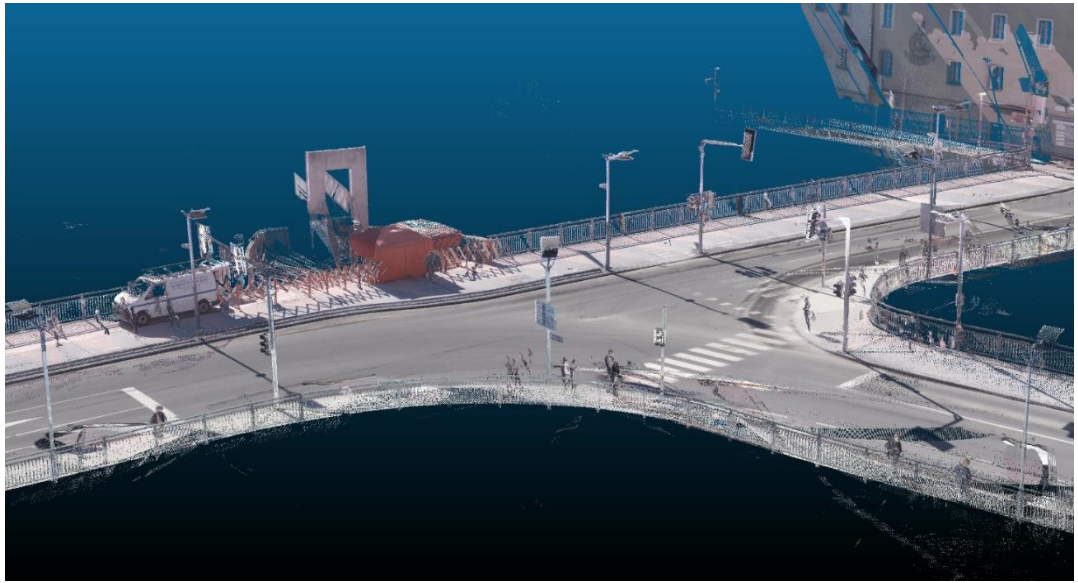
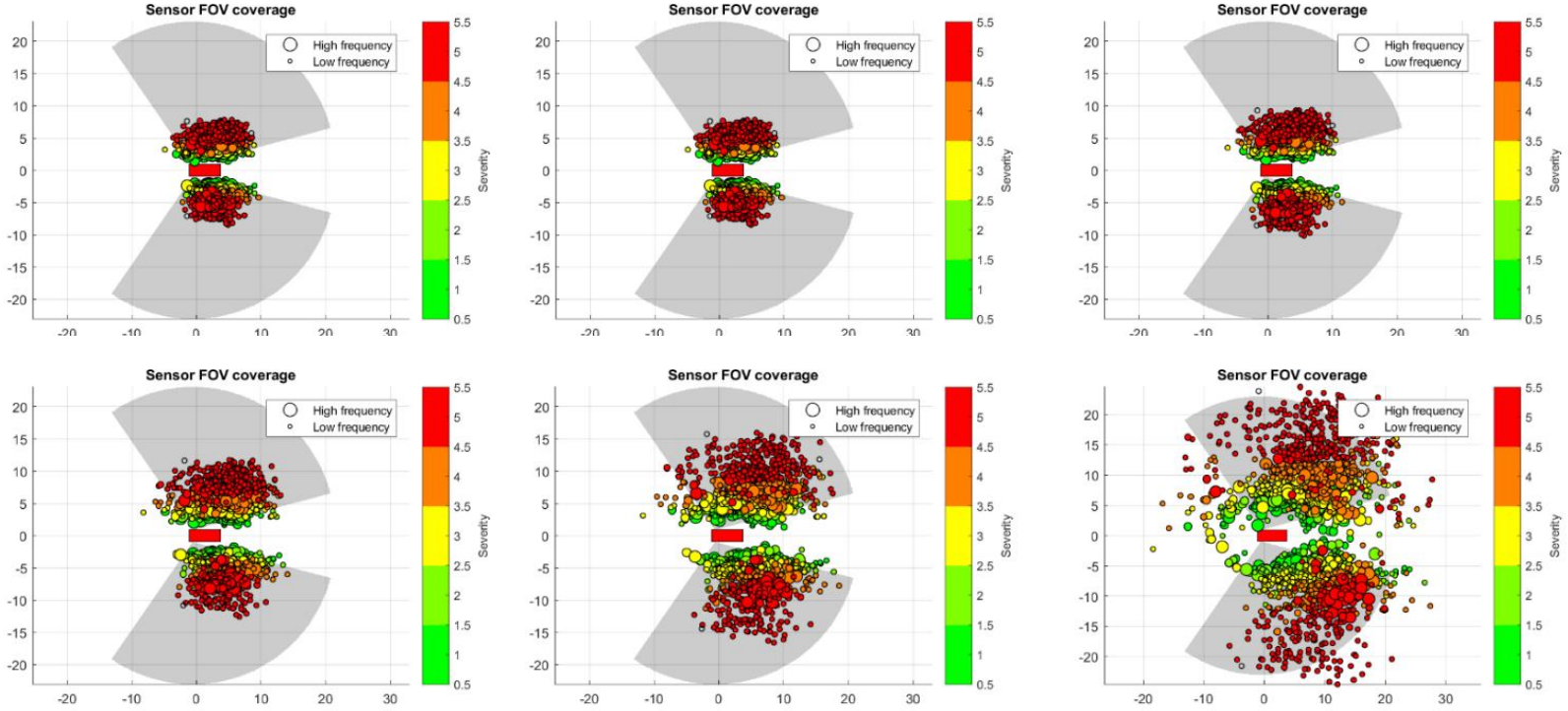
uHD Maps and „Digital Twins“

- UHD mapping based on mobile mapping data
- Combination of static and dynamic data in COPE Map
- Demonstration via app in vehicle / demo vehicle
-



Sensor & Data Analysis for Decision Times & Actions



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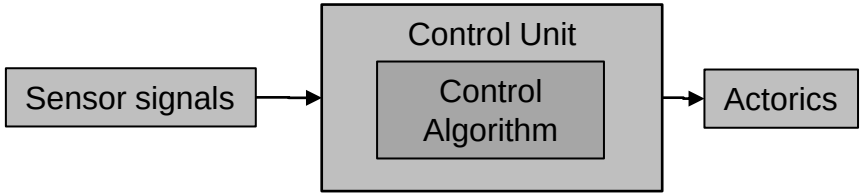
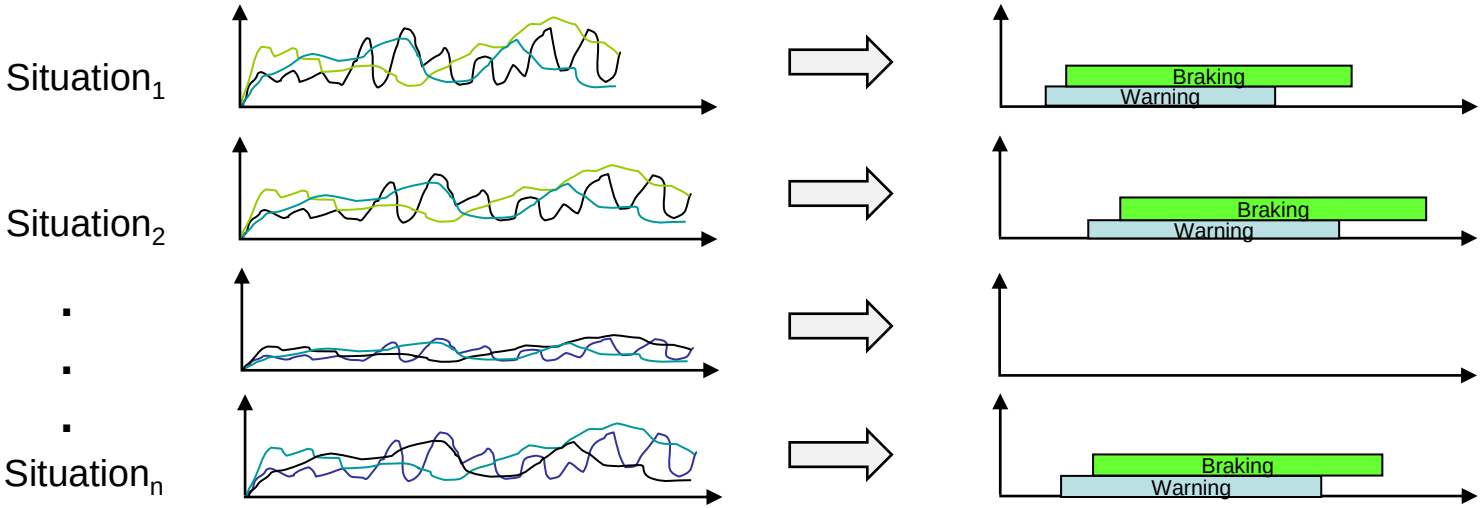
Example Based Representation of Functional Requirements



STIPULATOR



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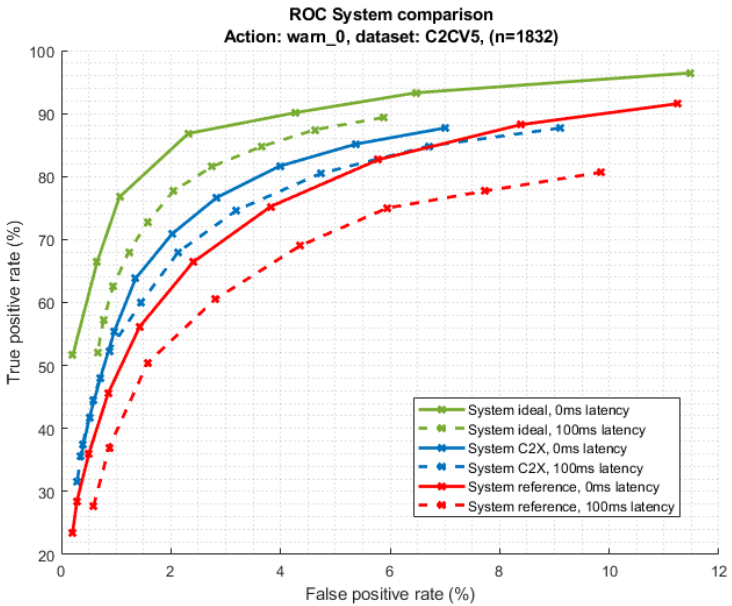
AI-based Evaluation of Data for Situation Interpretation



- Taking different information sets for the classification of the situations

➢ Numerical Conflict Analysis

➢ Feature engineering (including C2X-messages) to find best information/message content

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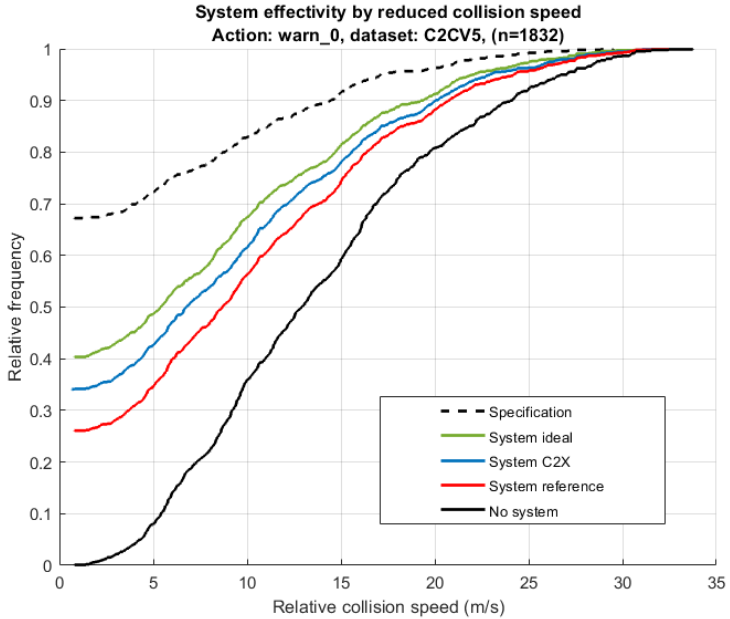
Effectiveness Assessment



- Identification of components with most influence on system performance
  - actions
  - sensors / data
  - informations / messages
  - algorithms

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Scenario Based Approach for Development and Validation of Traffic Automation Functions

Empirical Distributions and Models

- Test Fields
- Naturalistic Driving / FOT

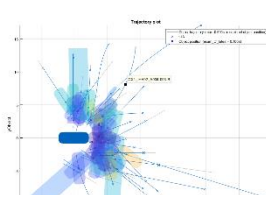
Implementations

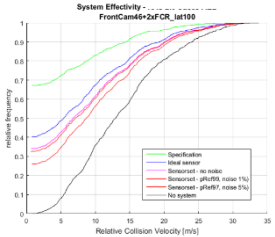
- Traffic Control Actions
- Vehicle Control Actions
- Traffic Situation
- Behavioral Models
- Infrastructure / Environment
- Laws & Regulation

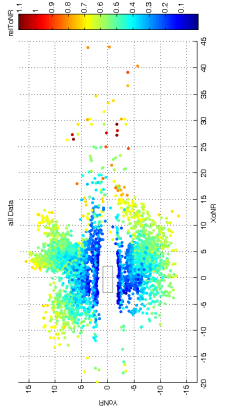
Scenario Catalog Simulation Base

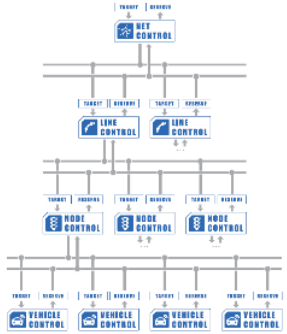
Evaluation of KPIs
- Criticality
- Reserves
- …

- Artificial Intelligence
- Big Data Analytics
- Robustness Mngt
- Complexity Mngt
- Effectiveness Rating
- Reference Systems
- System-of-Systems
- Conflict Analysis
- Cond. Probabilistics
- Var. Labellings
- Parametrized ODD
- …









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Conclusions & Outlook

- Scenario management combined with AI and effectiveness rating are the fundamental methods of choice for the development and validation
- Stochastic behavioral driver models (conditional prob., Bayes, …)
- Tight interconnection with test fields and NF/FOT to capture behavioral data
- Crisp description of assumptions & capabilities, ODD parametrization
- Collective Perception with local/decentral Digital Twins (where will the intelligence finally reside?)

➢ Project DIGEST (Digital Twins for Road Infrastructure)

bast ASFINAG Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra

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Thanks, for listening!

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ANDATA GmbH

Dr. Andreas Kuhn
Tel: +43 6245 74063
Email: andreas.kuhn@andata.at
Web: www.andata.at