Blickpunkt Forschung
Intelligent Intersection

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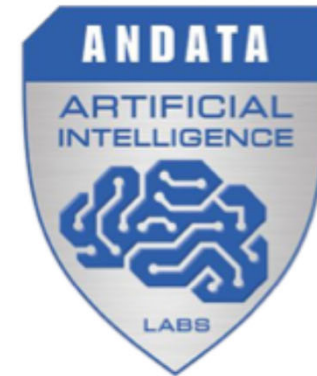[1]Institute of Telecommunications, TU Wien

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Partners and Associates

TU Wien — institute of telecommunications

TU Wien — institute of mechanics and mechatronics

ANDATA ARTIFICIAL INTELLIGENCE LABS

komobile BÜRO FÜR VERKEHRSPLANUNG

KFV Kuratorium für Verkehrssicherheit

swarco SWARCO FUTURIT Verkehrssignalsysteme Ges.m.b.H.

Stadt Wien MA 33 Wien Leuchtet
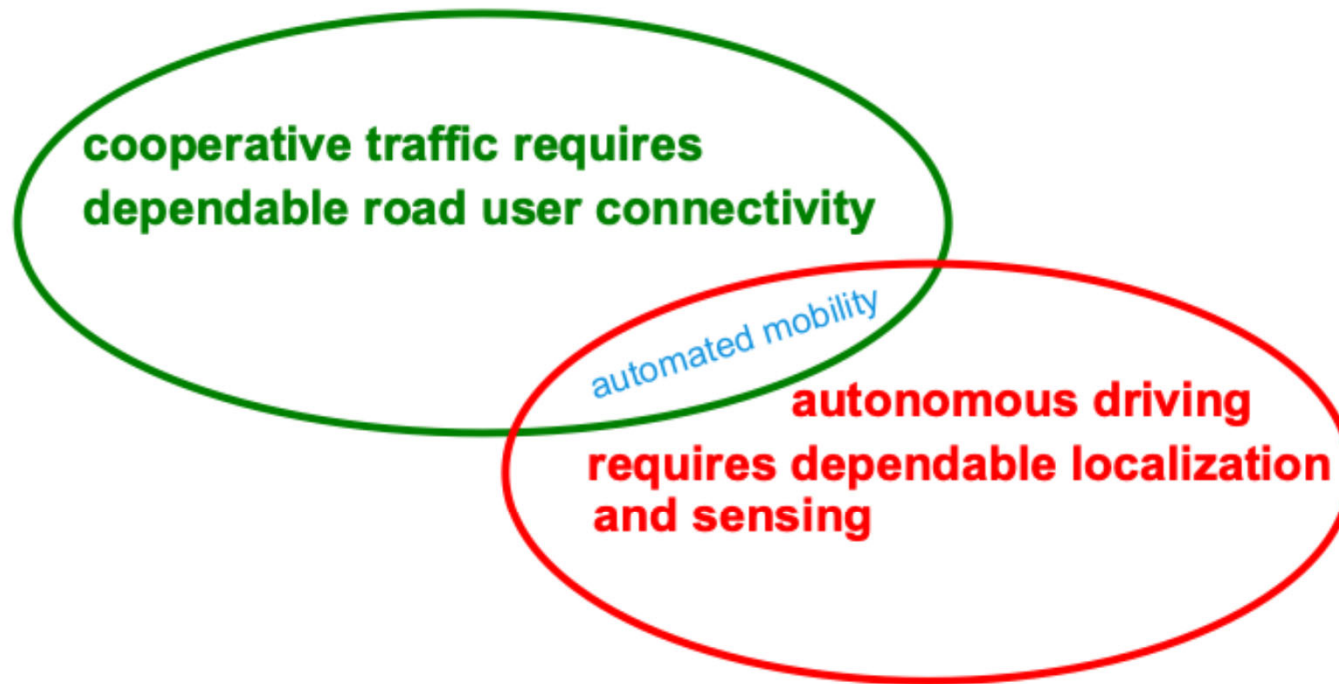
IntIntSec Challenge

Increasing traffic volumes in inner-city areas are exacerbating the conflict between safety, traffic efficiency and environmental pollution.

Intersections are critical nodes in traffic networks, which are currently mostly controlled by fixed, preset signal programs.

The aim is to make road traffic cleaner, safer and more efficient.

5G dependable connectivity, localization and sensing

cooperative traffic requires dependable road user connectivity

automated mobility

autonomous driving requires dependable localization and sensing

5G Localization and Sensing

- Road user positioning in Purkersdorf

- Enhances satellite-based navigation when satellite visibility is poor

- Positions and sensor data of road users are fused by edge computing and redistributed by 5G nodes at intersection
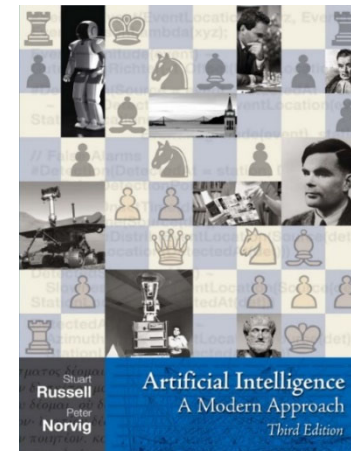
institute of telecommunications
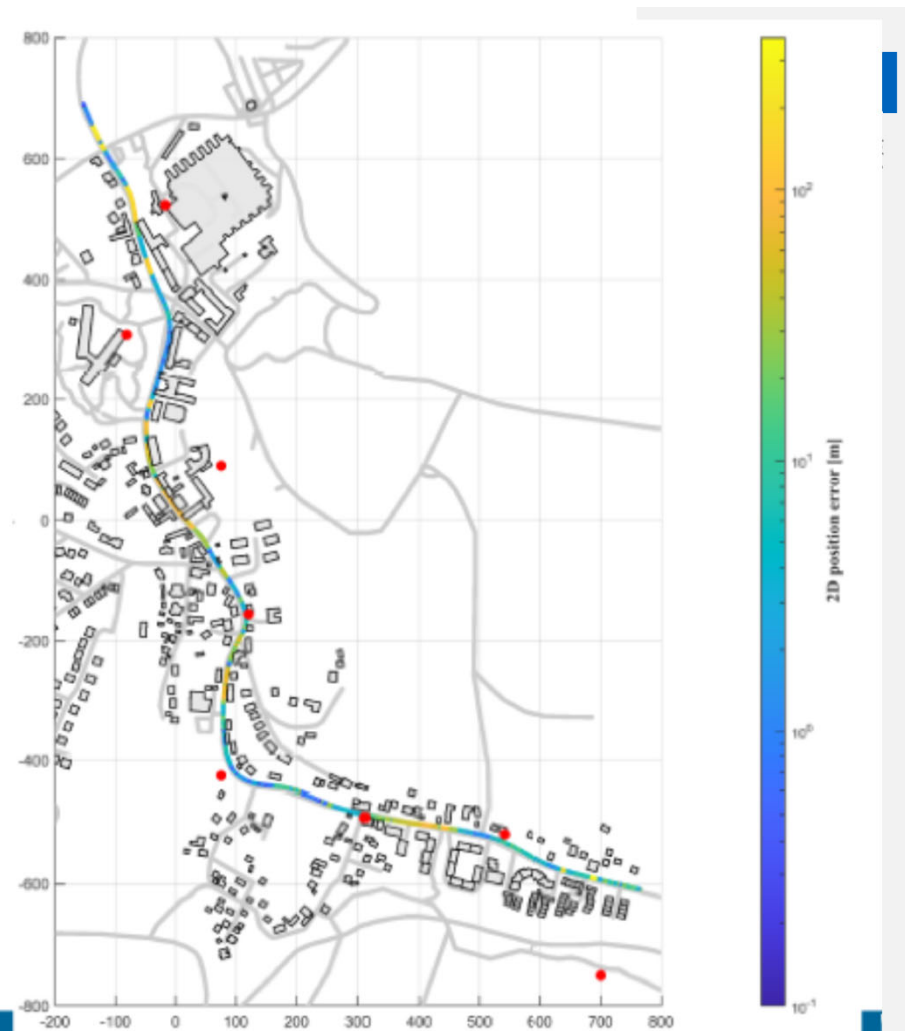
Prerequisites for „Intelligence"

Criteria for Intelligence (according to *Russel, Norvig: Artificial Intelligence, A Modern Approach, Chapter 2*)

- Detection and interpretation of the situation
- Judgement and pondering upon different action alternatives
- Adaption to changing environments and new situations
- Goal-oriented procedures

➢ „Intelligent Systems":
   ALL those criteria are in place

Stuart **Russell**
Peter **Norvig**
Artificial Intelligence
A Modern Approach
Third Edition

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Our Concept for the Intelligent intersection

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Scenario Management / Scenario-Based Development
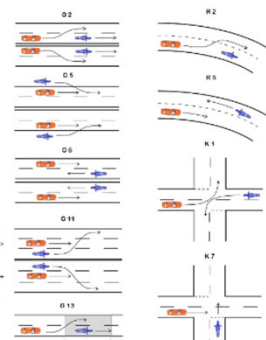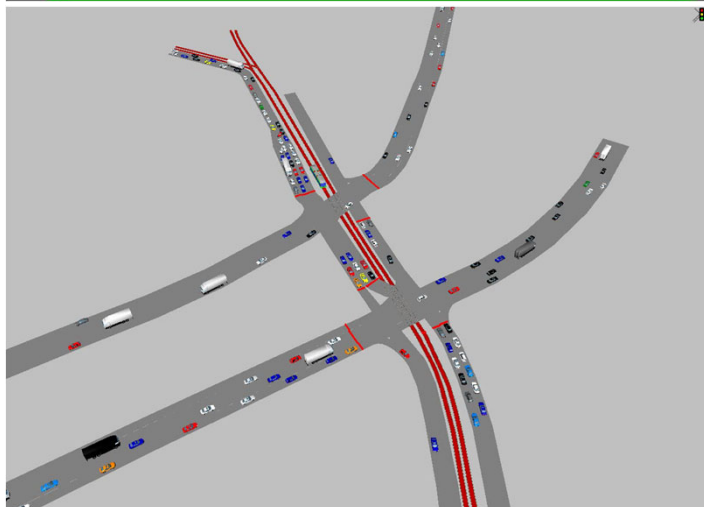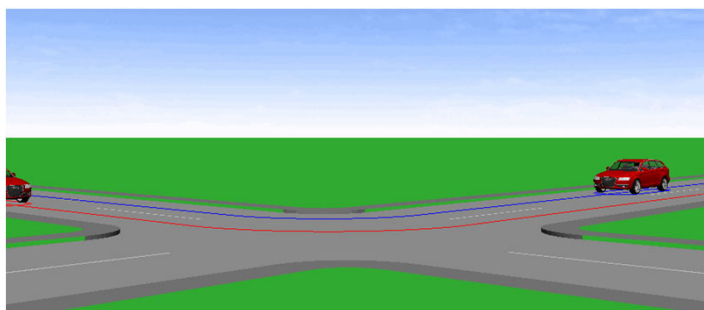
(Monte Carlo) Variations of
- actions and
- vehicle characteristics
- behaviours (driver/traffic)
- streets & environment
- traffic conditions
- traffic control
- communication

Scenario Management - Intelligent Intersection

VERONET

Empirical Distributions and Models

- Test Fields
- Naturalistic Driving / FOT

Implementations

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

Scenario Catalog Simulation Base

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

Evaluation of KPIs
- Criticality
- Reserves
- …

AI, Machine Learning
Situation recognition

AI, Machine Learning
Goals definition

AI, Machine Learning
Pondering between possible actions

AI, Machine Learning
Anomaly detection, adaption

Bing Maps Nutzungsbedingungen

Traffic Capacities E-W (Veh/h) — Action Existing, Action 1, Action 2, Action 3

Potential Conflicts (1/h) — Action Existing, Action 1, Action 2, Action 3

Total CO_2 Emissions (g/h) — Action Existing, Action 1, Action 2, Action 3

Identification and Clustering of the Relevant Traffic Situations
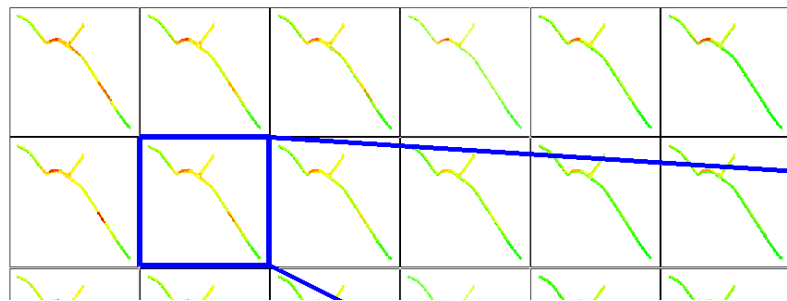
Time distribution of similar situations
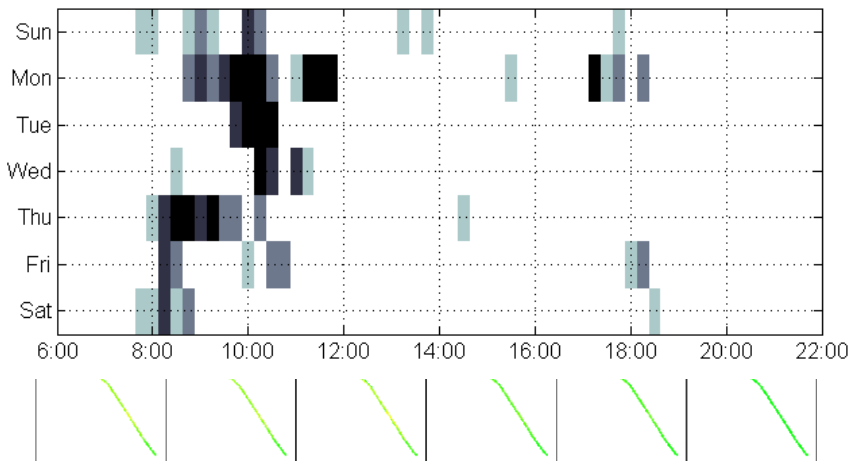
Automated evaluation of floating car data and various traffic sensors with machine learning

Map data © Google

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Collision Avoidance with Virtual Sensors (Machine Learning)
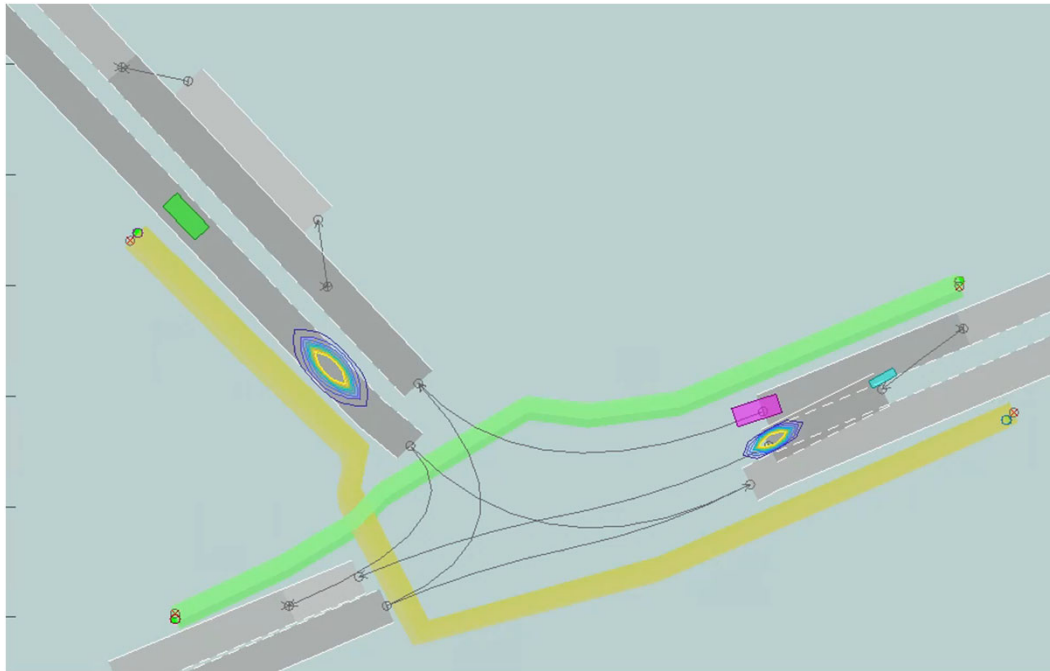
- Motion prediction by machine learning models
- Estimation of collision risks with virtual sensors
- Self-learning system, steady improvement with new data
- Digital Twin for trustworthy information exchange

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COPE 1

Outlook: Utilize Multi-Agent Information in Automated, Distributed, Safe Vehicle Control
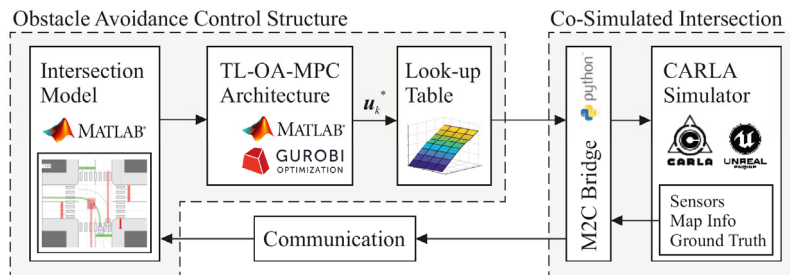
- **Model-predictive control (MPC)** of ego vehicle considers motion predictions of other vehicles:

  - **avoids obstacles** (mixed-integer QP)

  - plans a **safe, efficient trajectory**, including lane-changes & gap tracking
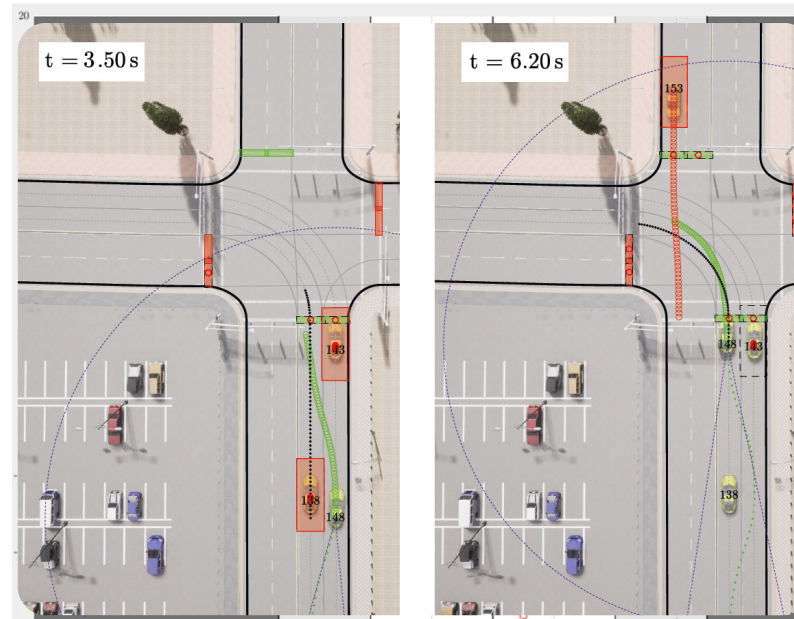
Co-simulation-based validation of OA-MPC with CARLA Simulator
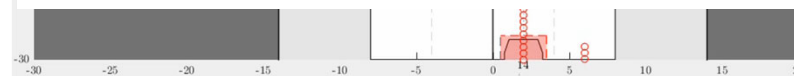
Safe, collision-free vehicle control achieved through obstacle-avoidance mixed-integer MPC solution

Summary

➢ Traffic control at intersections involves balancing **conflicting optimization goals**: intelligent solutions are necessary

➢ We propose such an **intelligent solution** by combining:
  – The **VERONET** architecture for distributed intelligence in the traffic automation
  – The **Digital Twin** architecture as cooperation platform

➢ The solution is also valid for intralogistics hubs or traffic control of AGVs, resulting in **swarm intelligence**.

This solution is **intelligent**:
  • Detection and interpretation of the situation ☑
  • Judgement and pondering upon different action alternatives ☑
  • Adaption to changing environments and new situations ☑
  • Goal-oriented procedures ☑