Institute of Cartography and Geoinformatics | Leibniz Universität Hannover

Sustainable Urban Mobility

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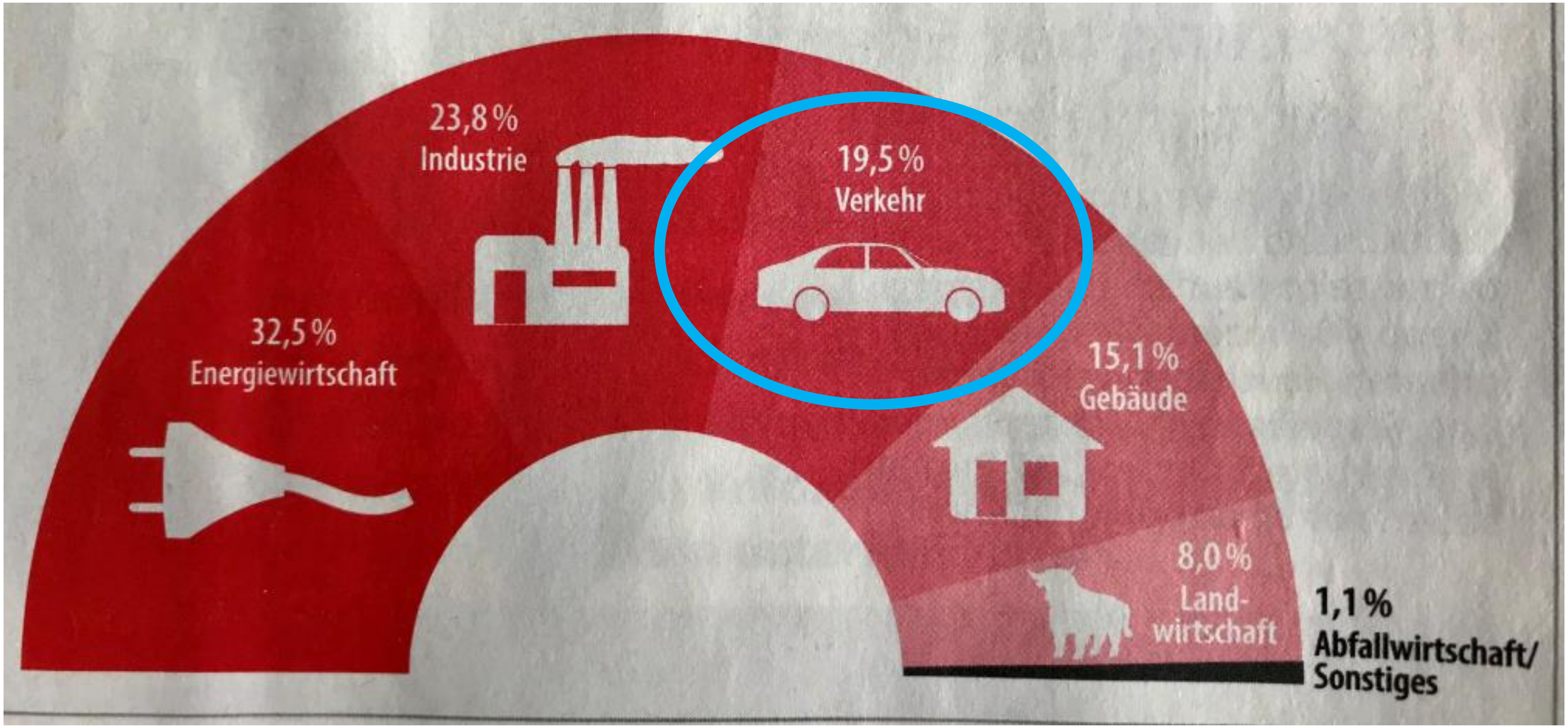
CO2-Emissions in Germany



Sustainable Solutions

- There is an urgent need to convert mobility systems worldwide to sustainable solutions
- Sustainability is often pursued through the principles of reduce, shift, avoid:
  - **Reduce** Reduction of energy or resources (e.g. land consumption) through the use of more energy-*efficient* / environmentally friendly technologies
  - **Shift** from car to public transport, or to active or shared forms of mobility
  - **Avoid** of journeys by not making them in the first place, replacing a journey with an online activity or choosing a closer destination that can be reached by active mobility (sufficiency: as much mobility as necessary)

Goal: Accessibility

- Mobility and accessibility -> central prerequisites for
  - social integration and participation,
  - exchange,
  - employment and prosperity in our society.

- Transport causes many **negative environmental impacts**
  - through the emission of greenhouse gases, air pollutants and noise
  - **high consumption of resources,** especially also **space**

- Traffic cuts into **liveability of our cities** and **public health**

Adaptation possibilities

- Addressing infrastructure and the commons
  - urban planning, transport planning, policy setting, …
- Addressing **individual behaviour** and culture
  - Mobility demand and mobility behaviour

- Exemplary questions:
  - How can basic functionalities of life become accessible without investing time and money in motorised trips? (-> e.g. **15 min city**)
  - How can **regulatory frameworks** support the behavioural shift to more local lifestyles (e.g. city entrance fees)
- Need:
  - **tools to assess the impact** of any intervention at system scale -> *spatial and spatiotemporal* simulation, data analytics, and prediction
  - **create awareness** and also transparency about mobility effects and also about alternatives -> communication and visualization

Intelligent mobility - space requirements - multiple utilization concepts: socially acceptable

https://futuremobilityfinland.fi/vision/seamless-intermodality-and-connectivity/ [23/09/2023]

- Space
  - traffic space,
  - recreation area, attraction
  - area for water storage/retention, ...
- Space as a finite resource in the city
  - for different needs
  - at different times
  - by different stakeholders
- Flexible space allocation?

If we know at all times ...

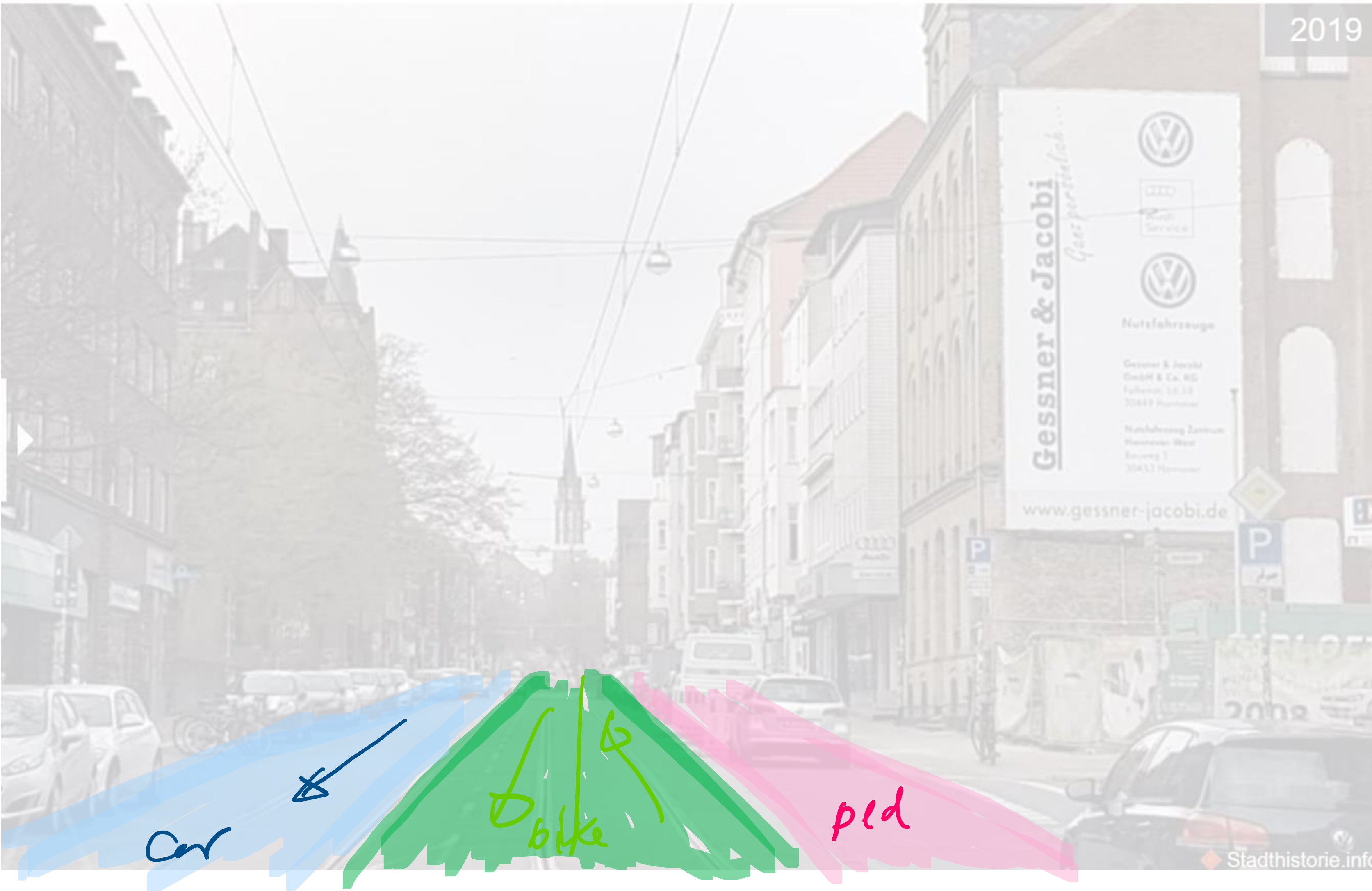
- What the needs are, e.g.
- How many cyclists there are at peak times
- When a courier service needs a parking space ...
- What is required in emergencies, e.g.
  - heavy rain -> retention areas
  - major event -> optimal traffic routing

- … then the space can be optimally allocated and used


2019
Gessner & Jacobi
Ganz persönlich...
Audi Service
Nutzfahrzeuge
www.gessner-jacobi.de
Stadthistorie.info

Traffic regulation during week

Traffic regulation at weekend



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- … then the space can be optimally allocated and used

Necessary for this: "digital reality (digital twin)"

In the following: examples of work at ikg

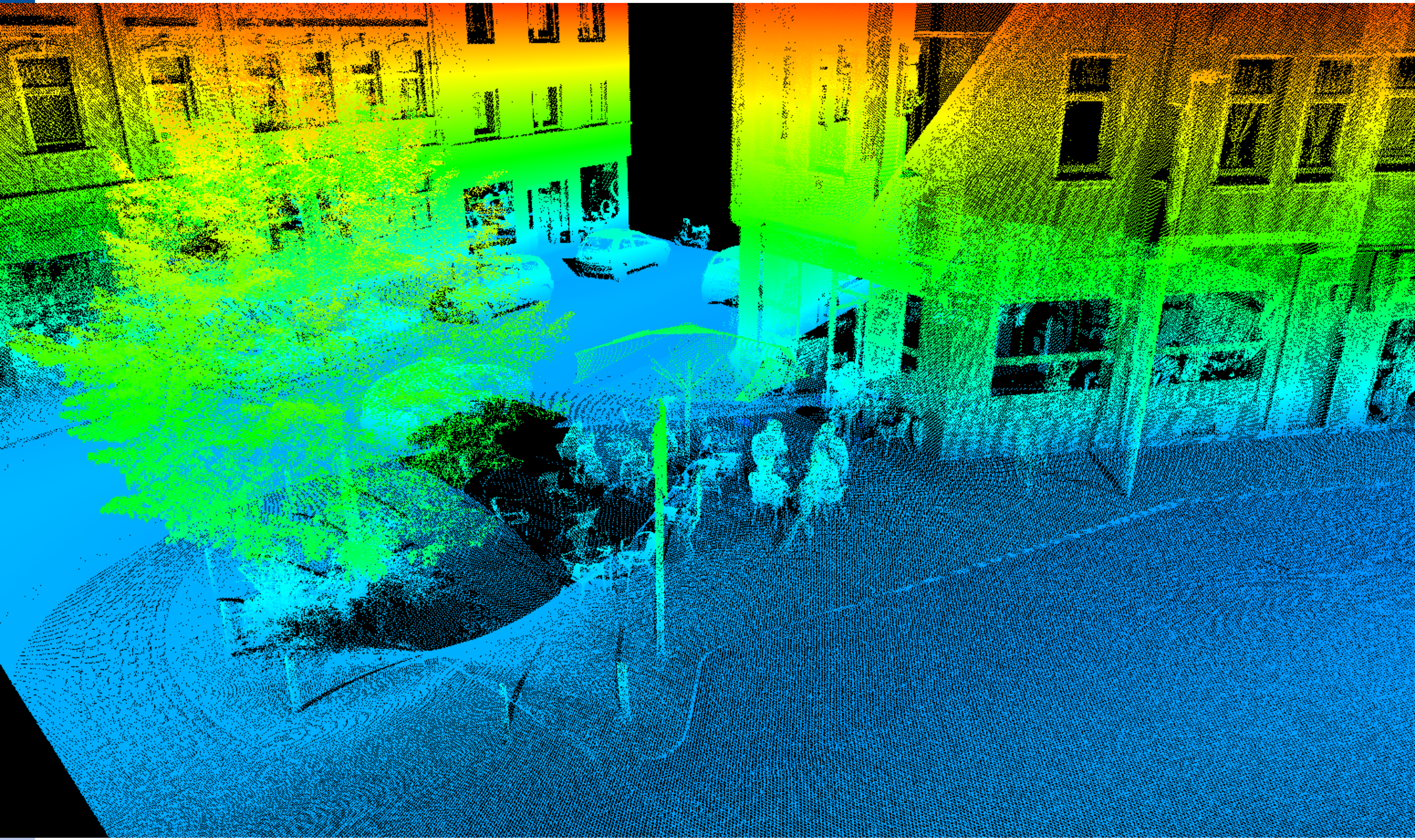
Capturing dynamic environmental information for autonomous driving using mobile mapping

Claus Brenner

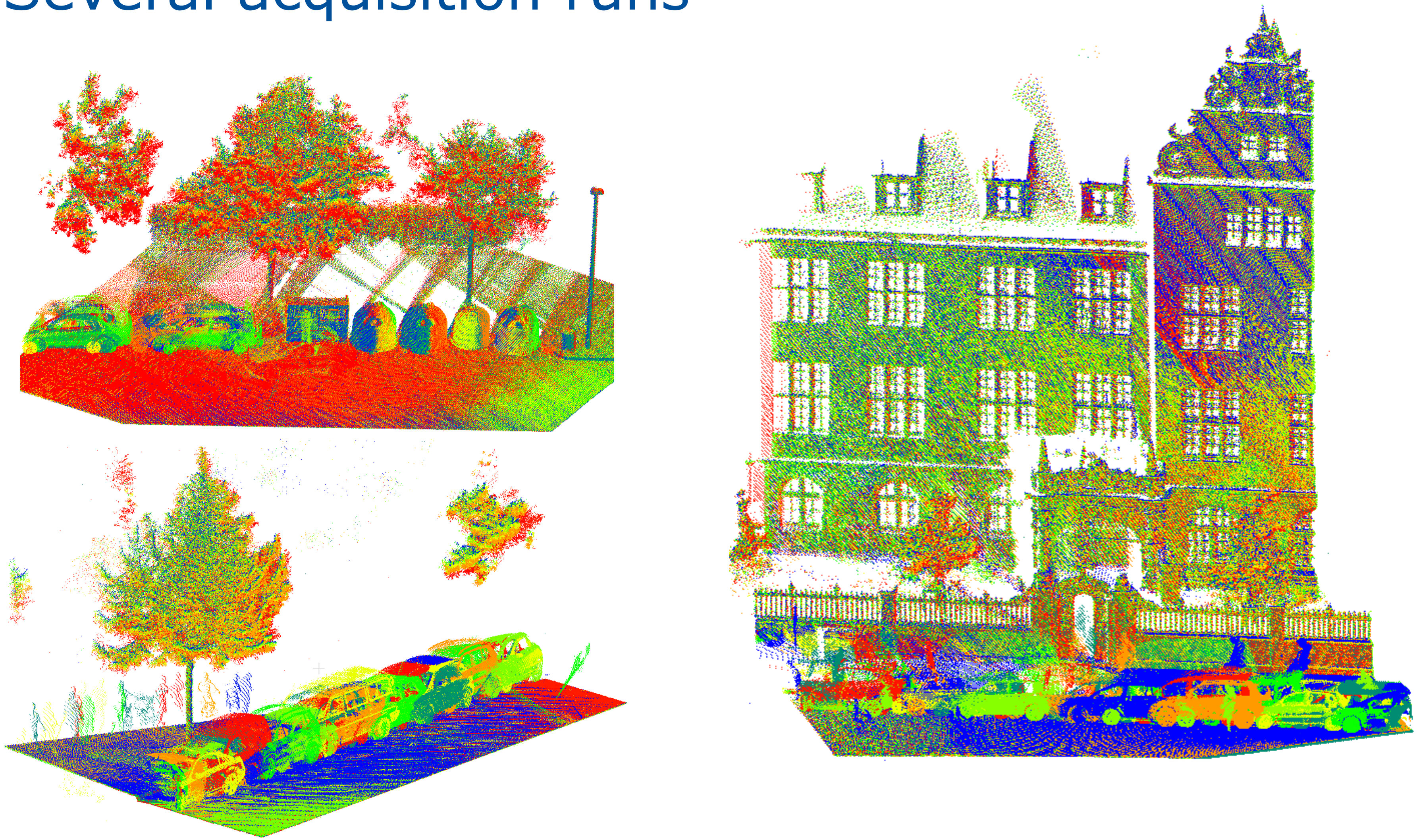
DFG-Graduiertenkolleg i.c.sens

Mobile Mapping Van

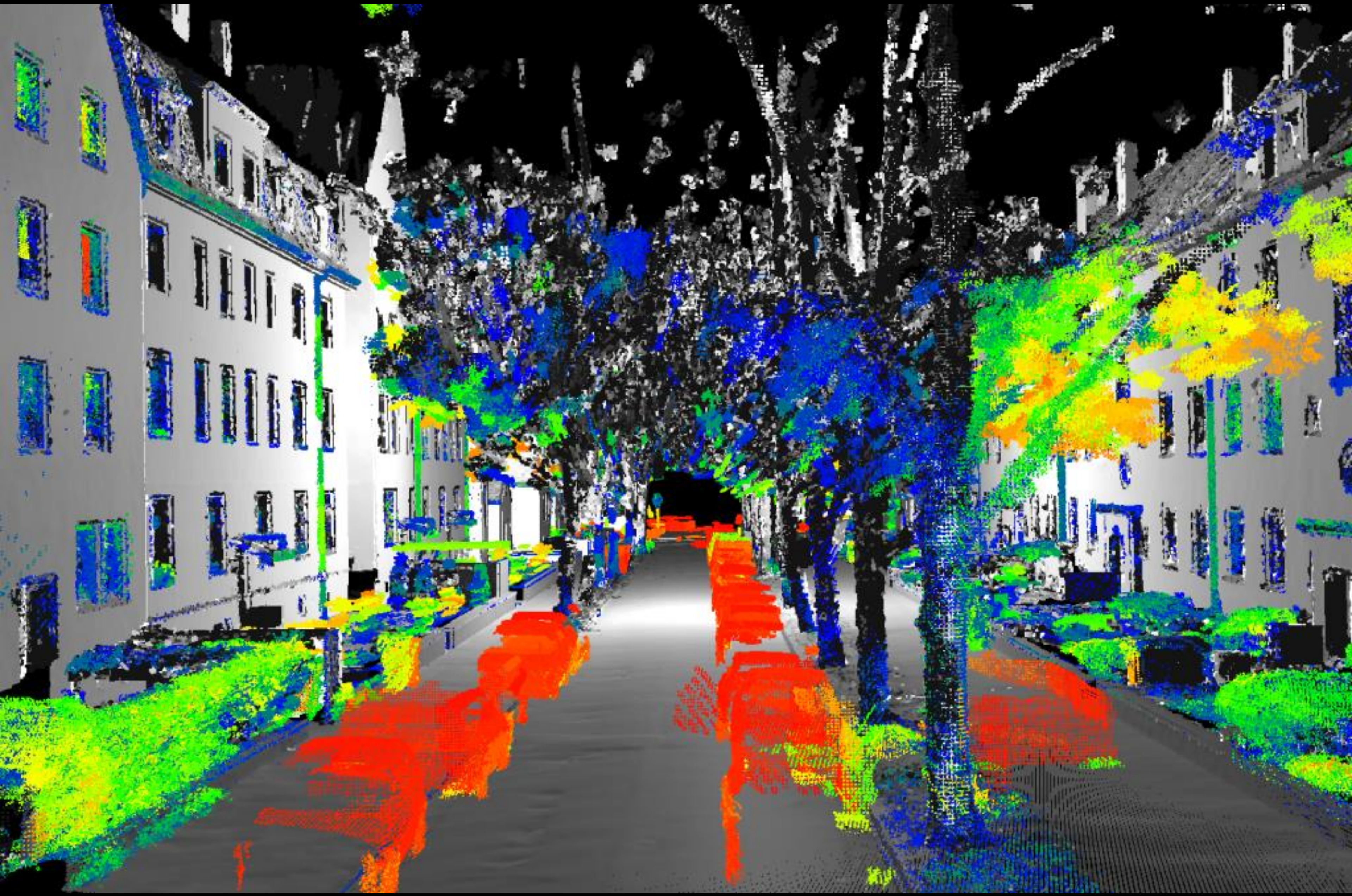
- Riegl VMX-250, 600k points/s



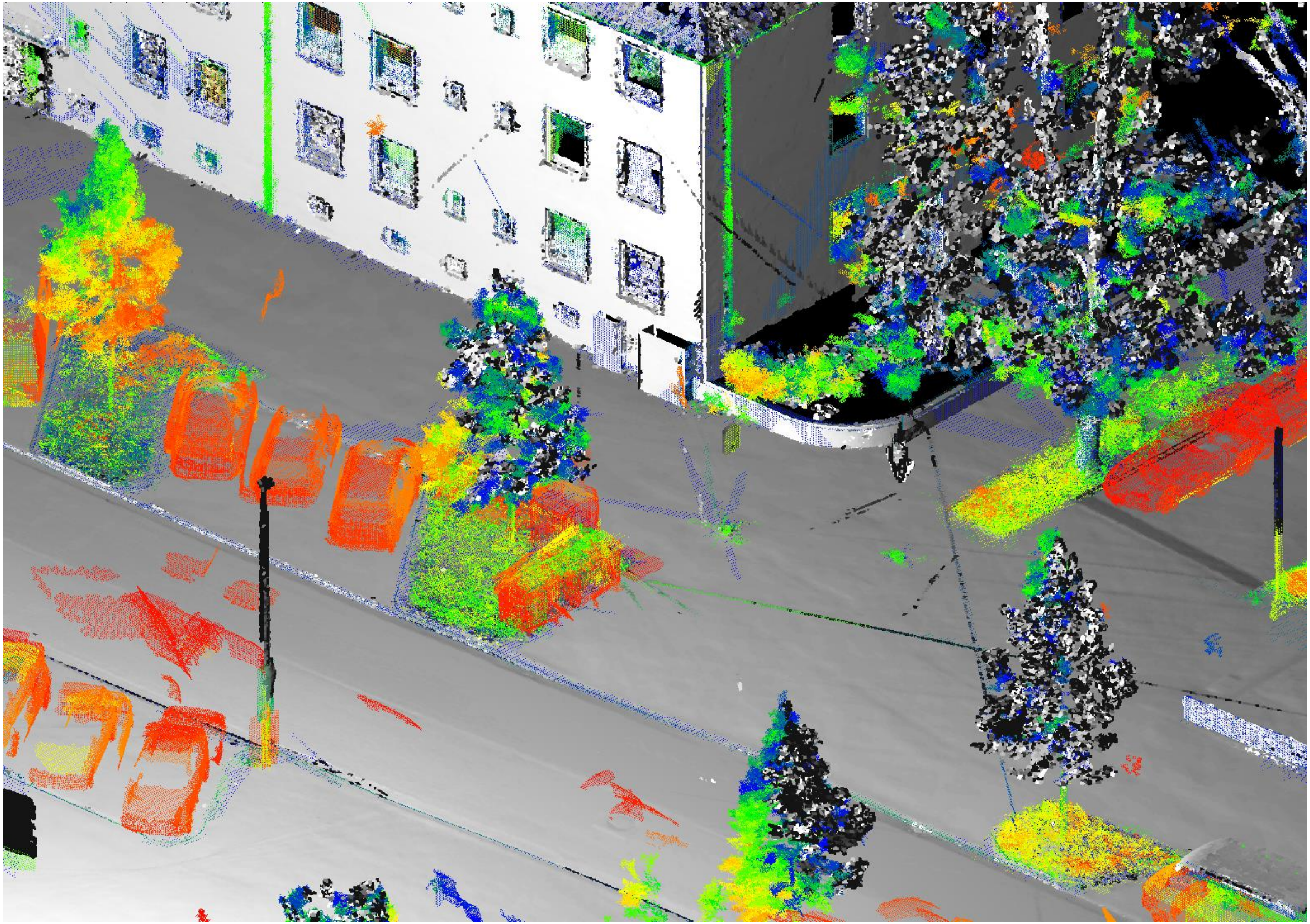
Several acquisition runs



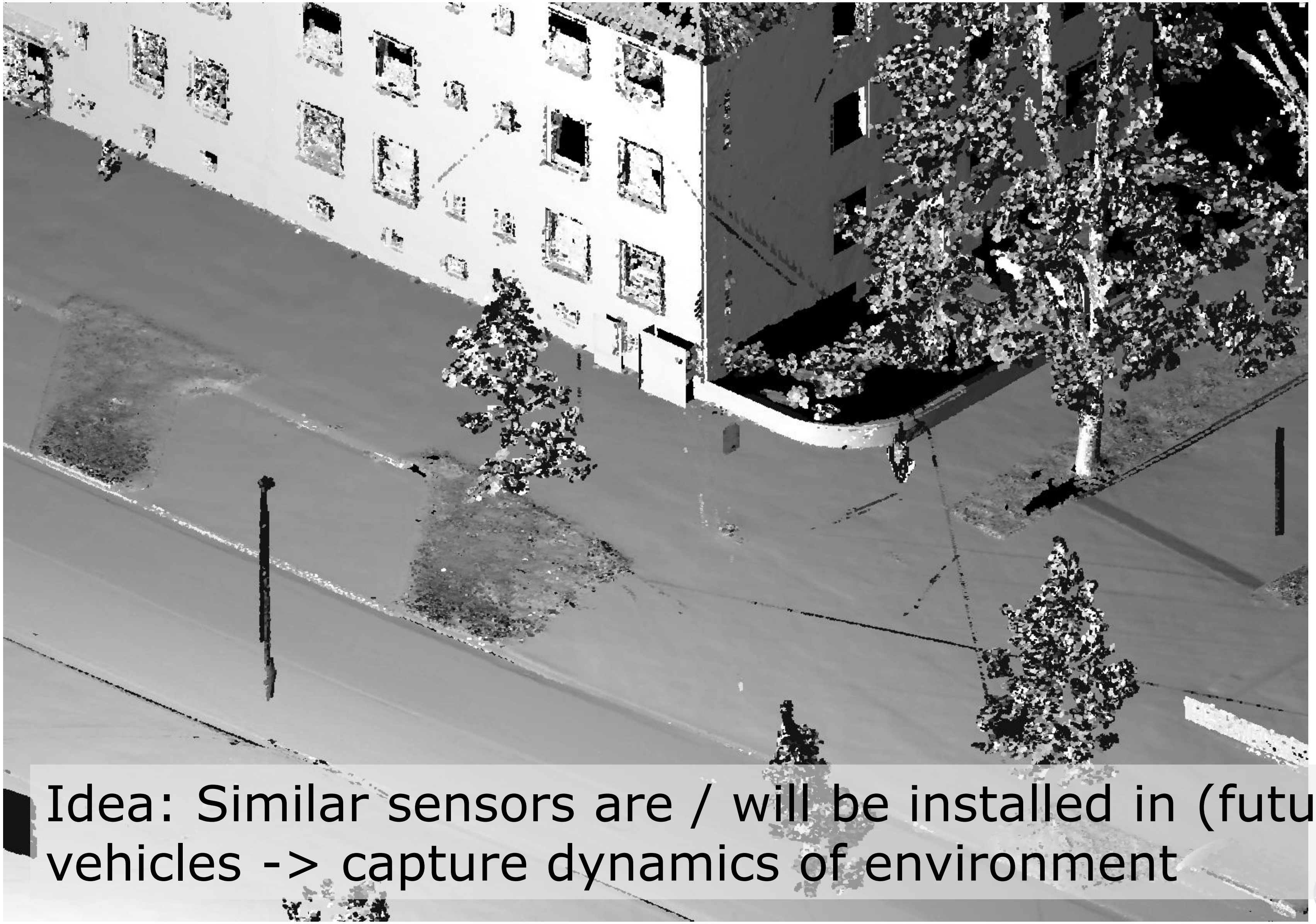
Example point clouds from seven measurements, colored by run id



Change detection

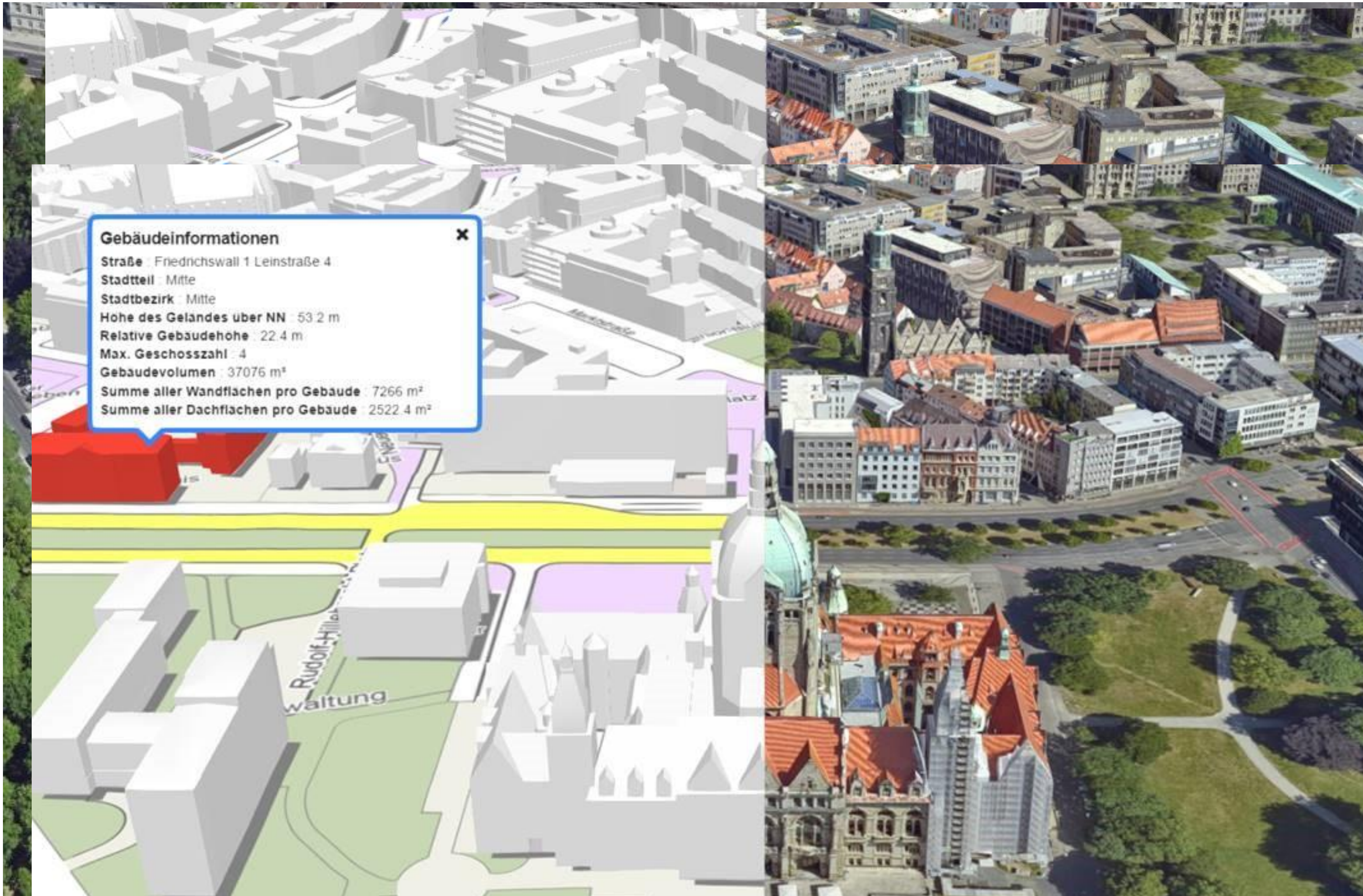


Change detection



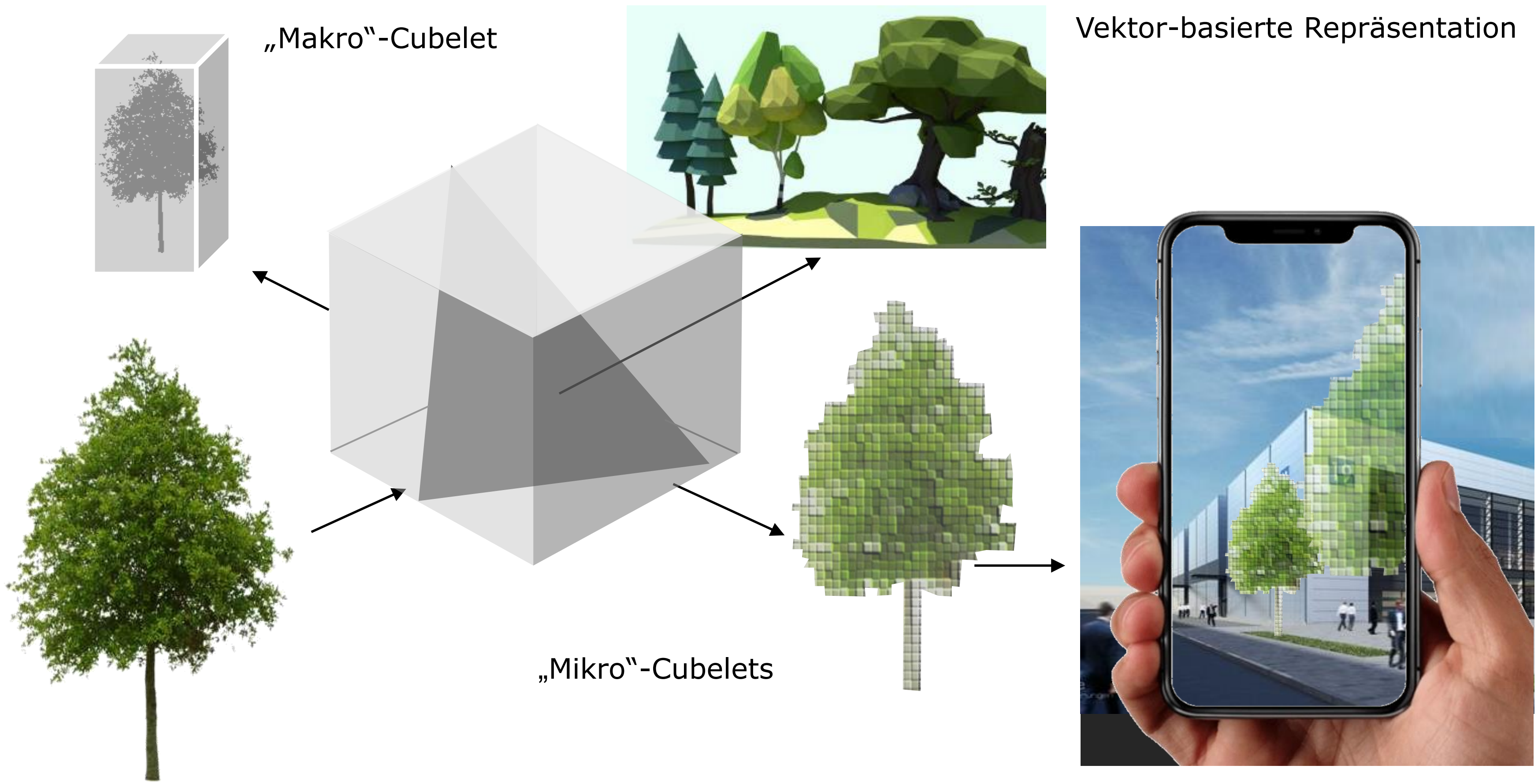
Idea: Similar sensors are / will be installed in (future) vehicles -> capture dynamics of environment

Reality ... and virtual image (digital twin)

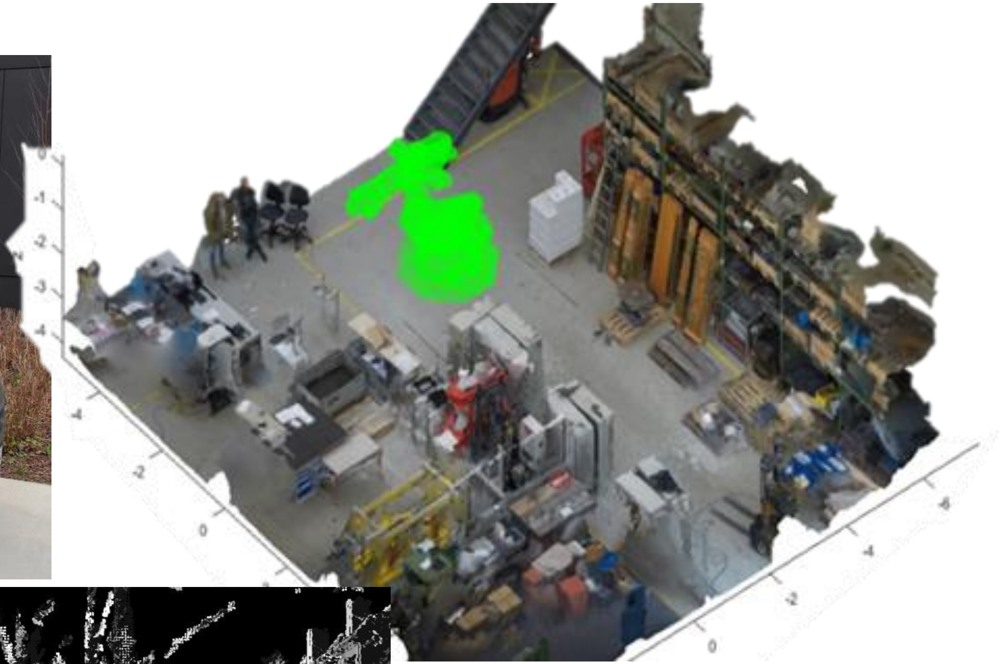


Project 5GAPS

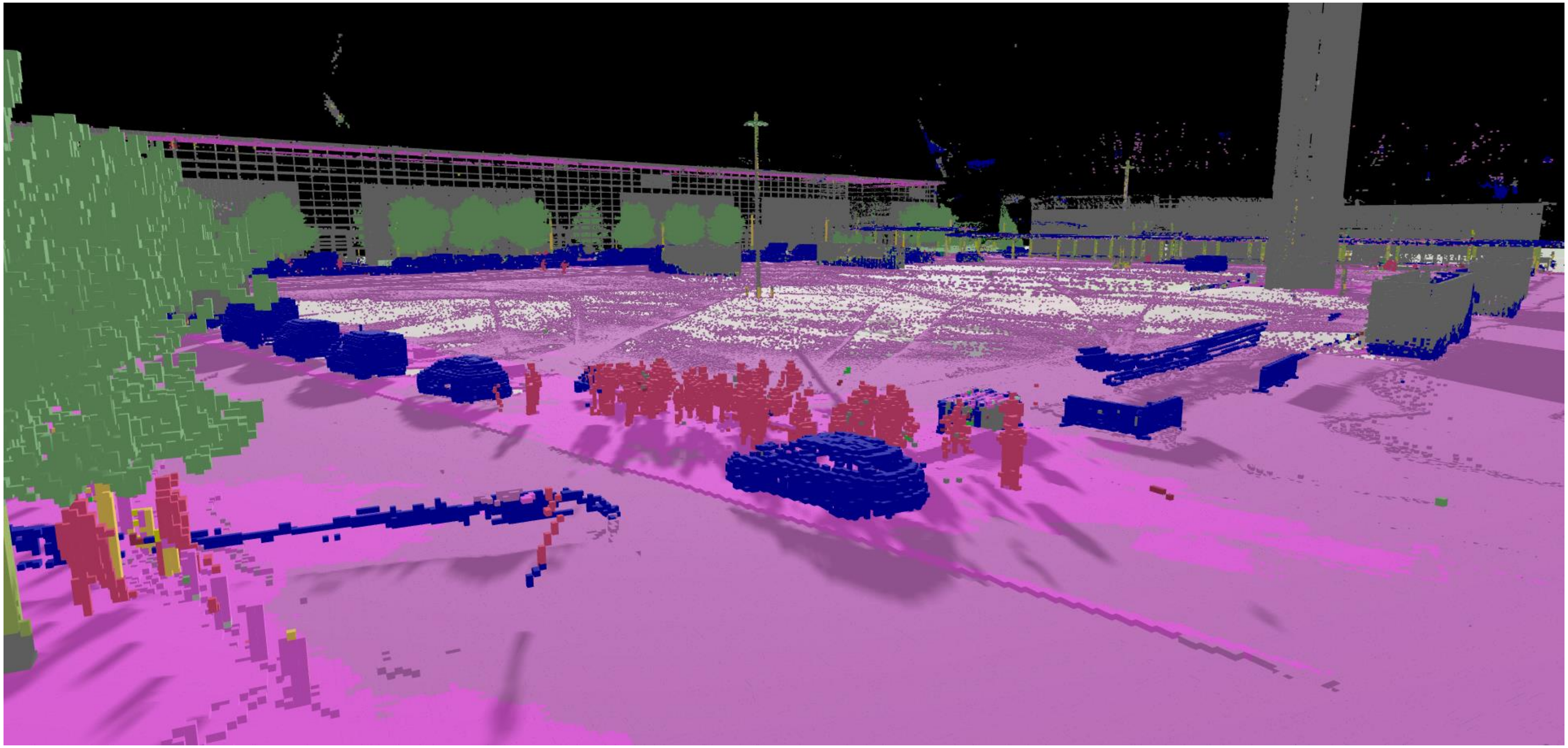
Cubelet-Plattform: multi-scale, multi-geometry, time



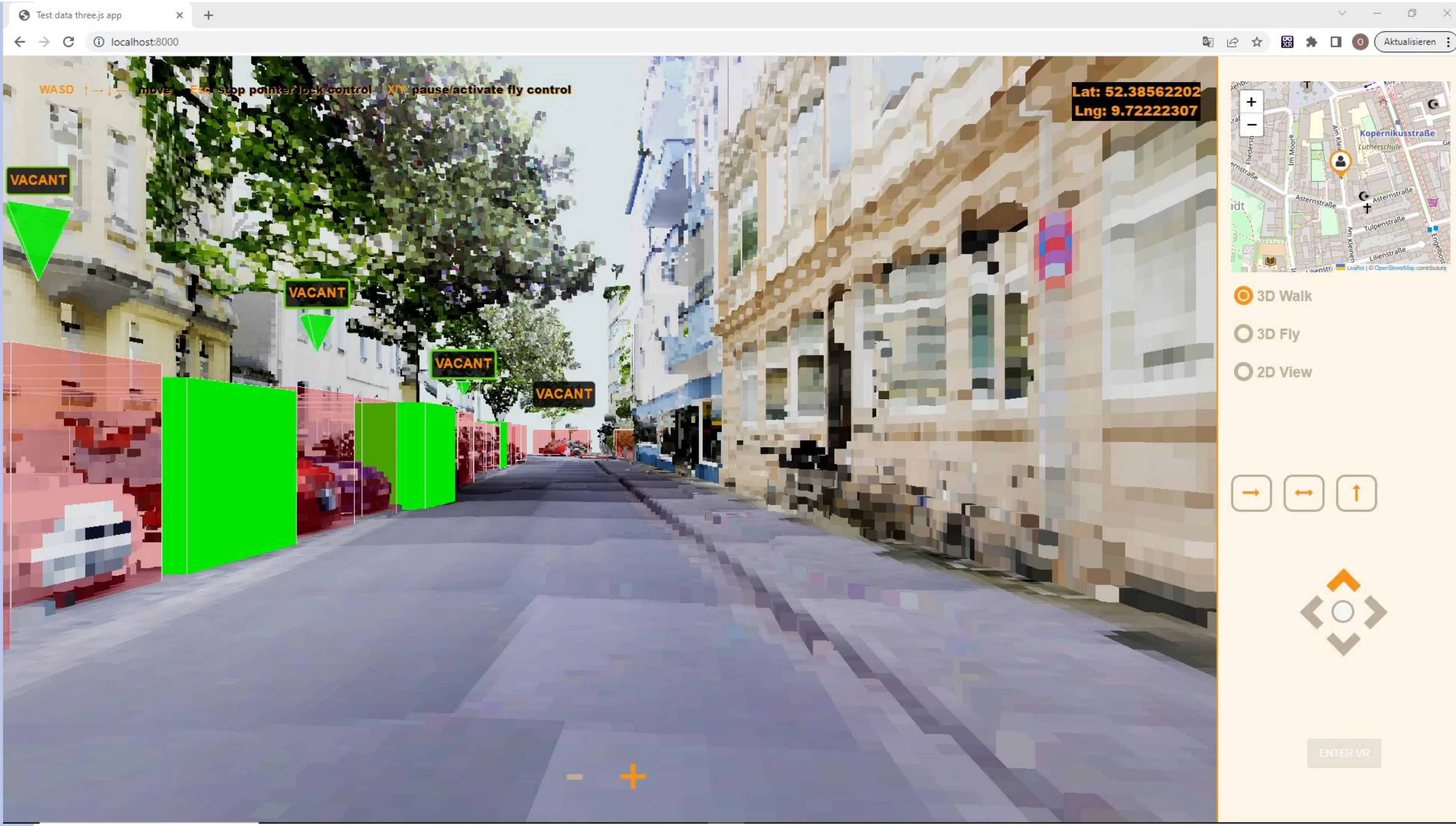
Data acquisition outdoor (city of Hanover) / indoor (trade fair)



AI based semantic classification of point clouds



Application:
Macro-Cubelets for parking management



Predict dynamics of traffic participants:

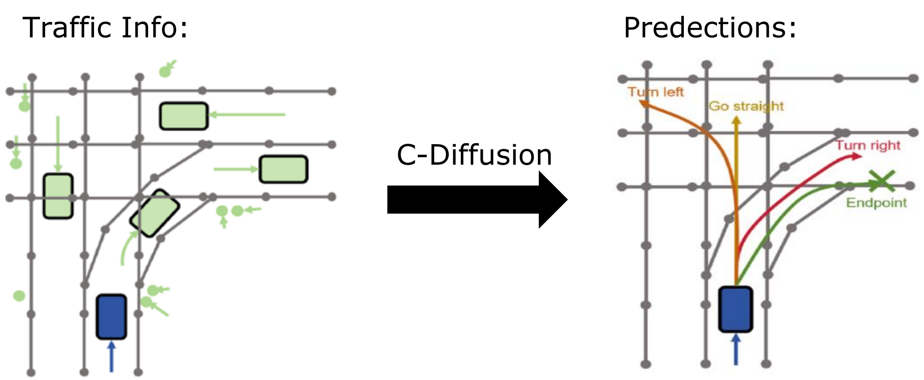
Controllable Diverse Sampling for Diffusion Based Motion Behavior Forecasting

Yiming Xu

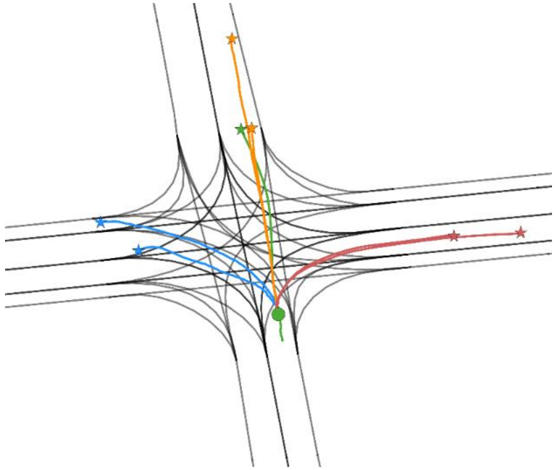
Motivation – learning future trajectories

- Future trajectory depends on
  - Intention - behaviour
  - Environment
  - target
  - Neighboring traffic participants
- Usually: only one ground truth trajectory given

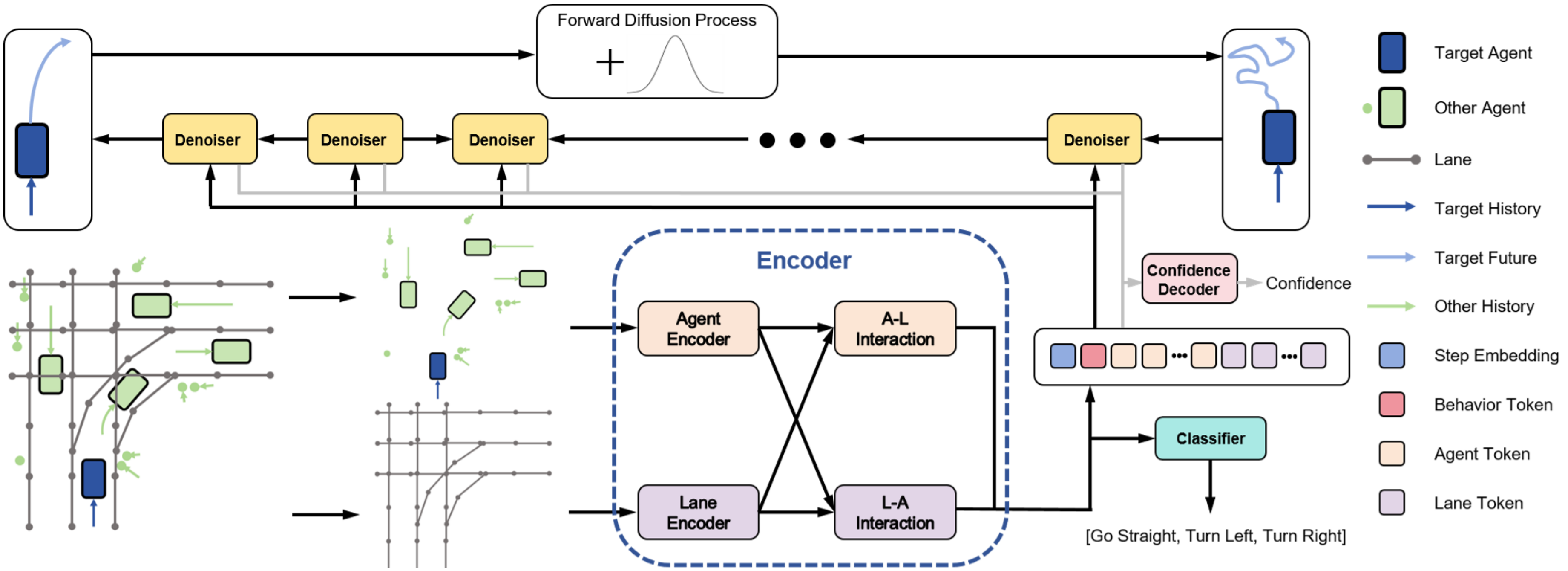
Idea:



Result: Diverse predictions

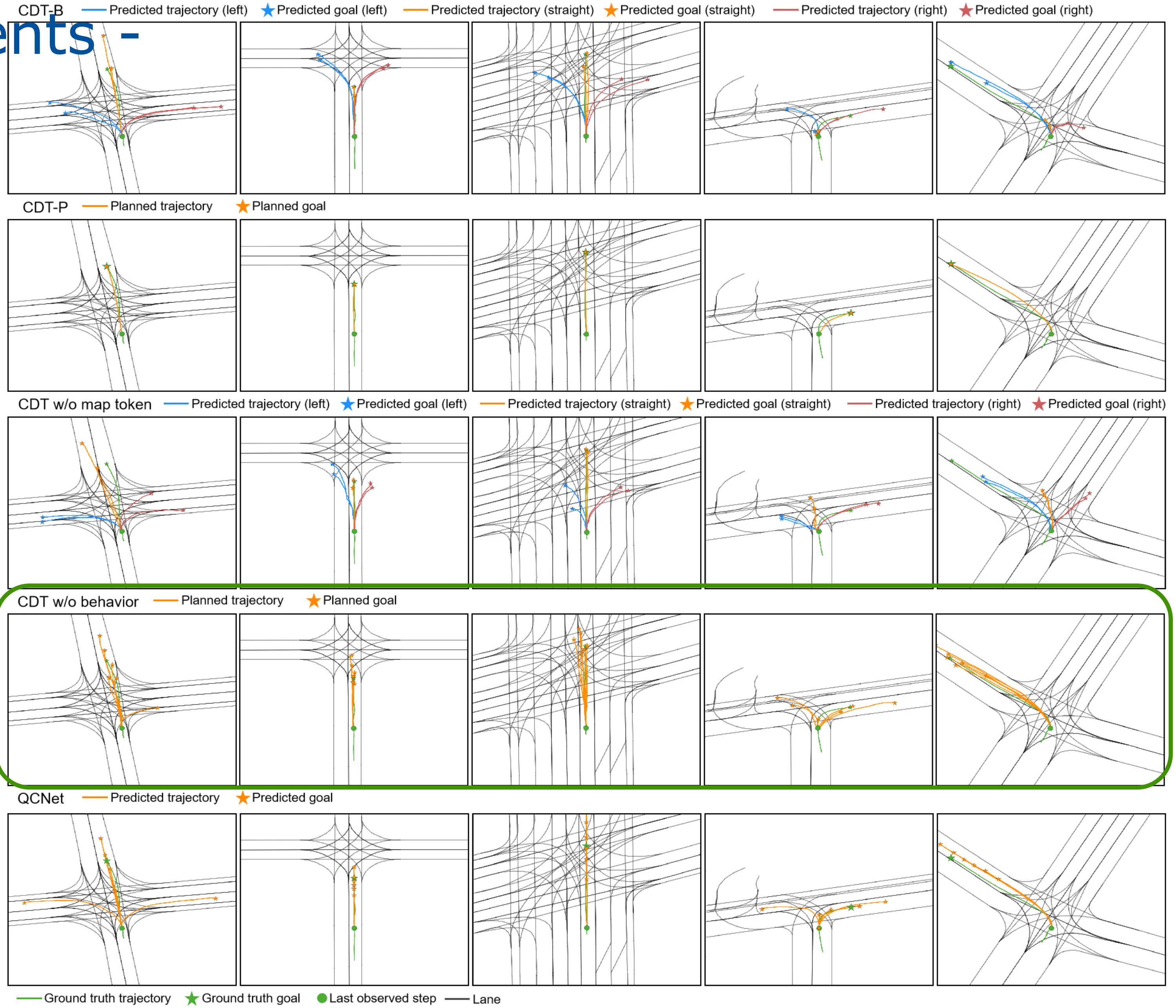


CDT-Network



Y. Xu, H. Cheng and M. Sester, "Controllable Diverse Sampling for Diffusion Based Motion Behavior Forecasting," *2024 IEEE Intelligent Vehicles Symposium (IV)*, Jeju Island, Korea, Republic of, 2024, pp. 2397-2404, doi: 10.1109/IV55156.2024.10588486

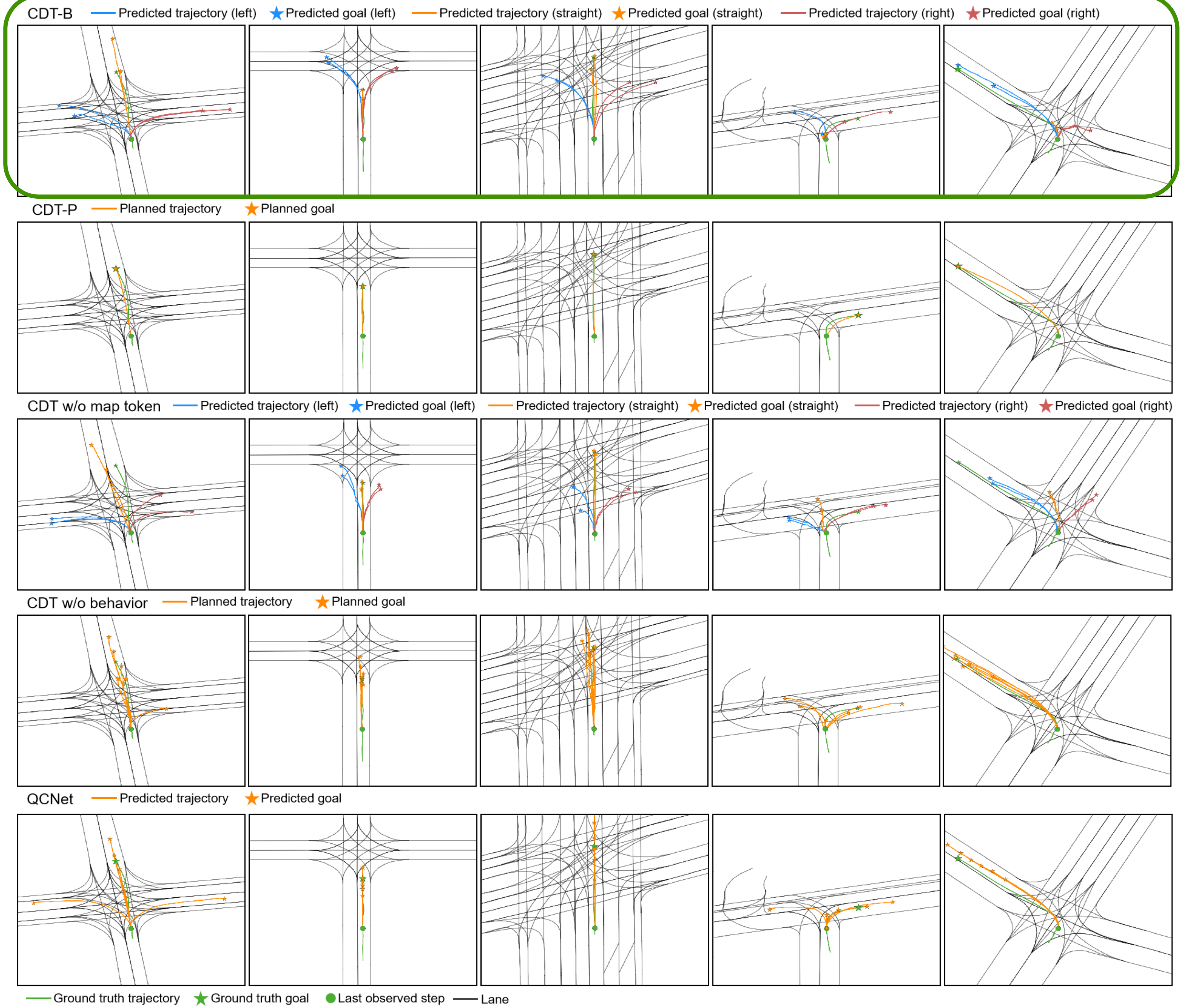
Experiments - ablation



No behaviour

- CDT property: generating diverse and scene-compliant trajectories in complex urban settings

Experi-ments



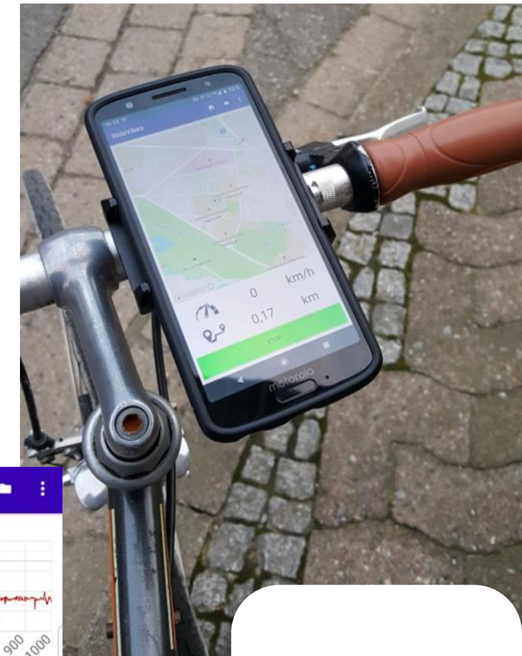
- CDT property: generating diverse and scene-compliant trajectories in complex urban settings

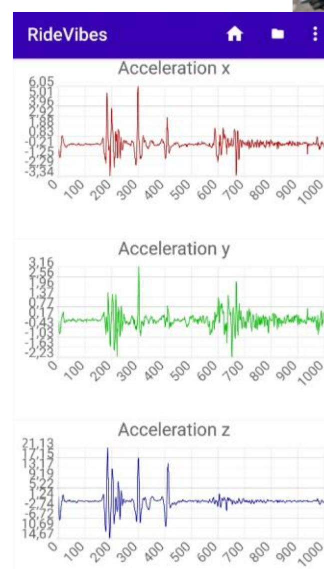
Active mobility: mapping cycle path roughness / comfort using crowd sourcing

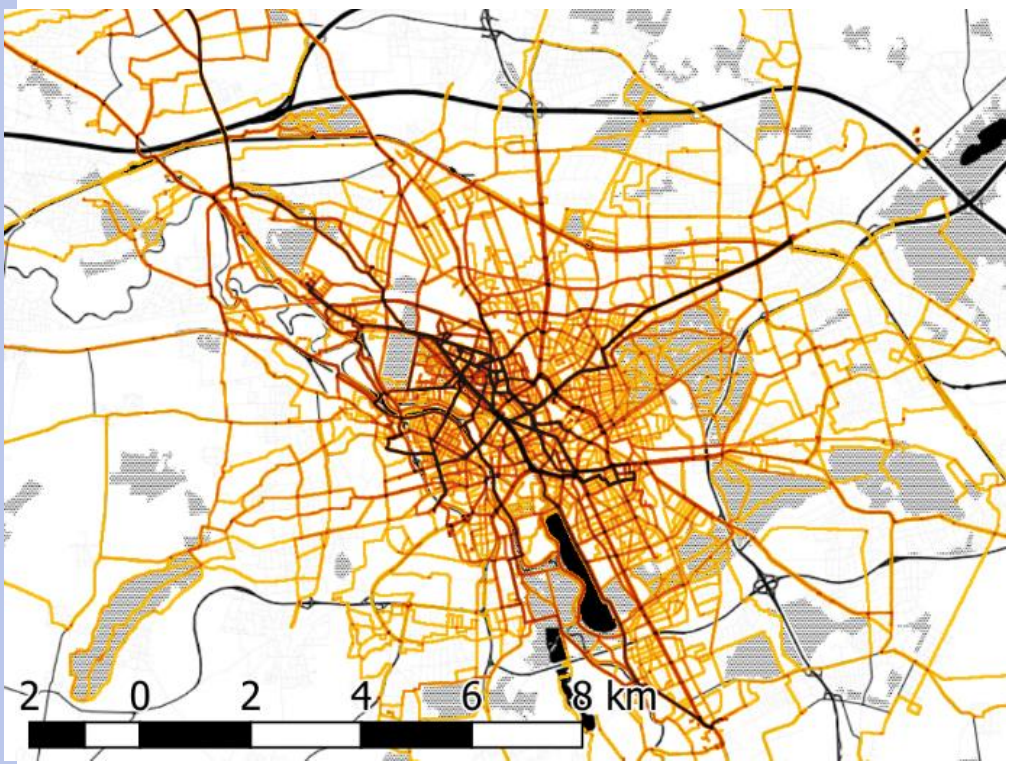
Oskar Wage

Data acquisition

- Recording of position and acceleration data with smartphone on the bike handlebars
- Simple tracking of daily journeys







RIDE VIBES

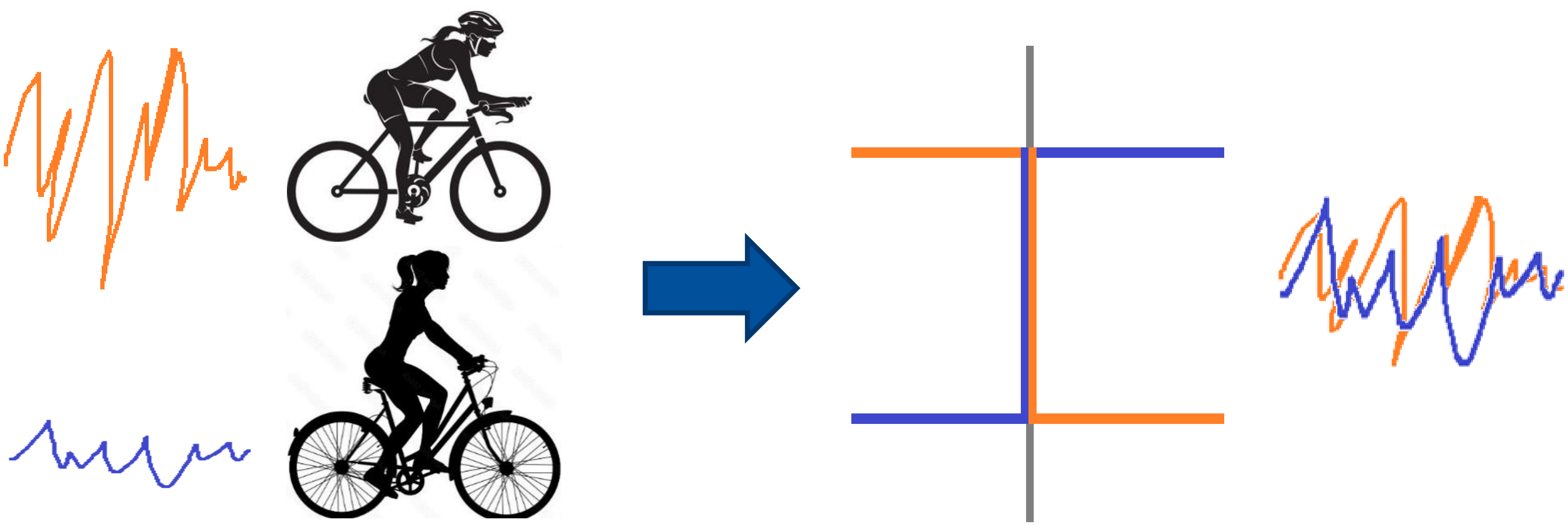
Processing Approach

- Previous work
  - Road roughness from acceleration measurements
  - Only for individual (measuring) bicycles with fixed settings, which must travel all routes
- Problem
  - Detected roughness varies depending on user, bike and general environment

- Here: an approach to harmonize the observations of different bicycle configurations

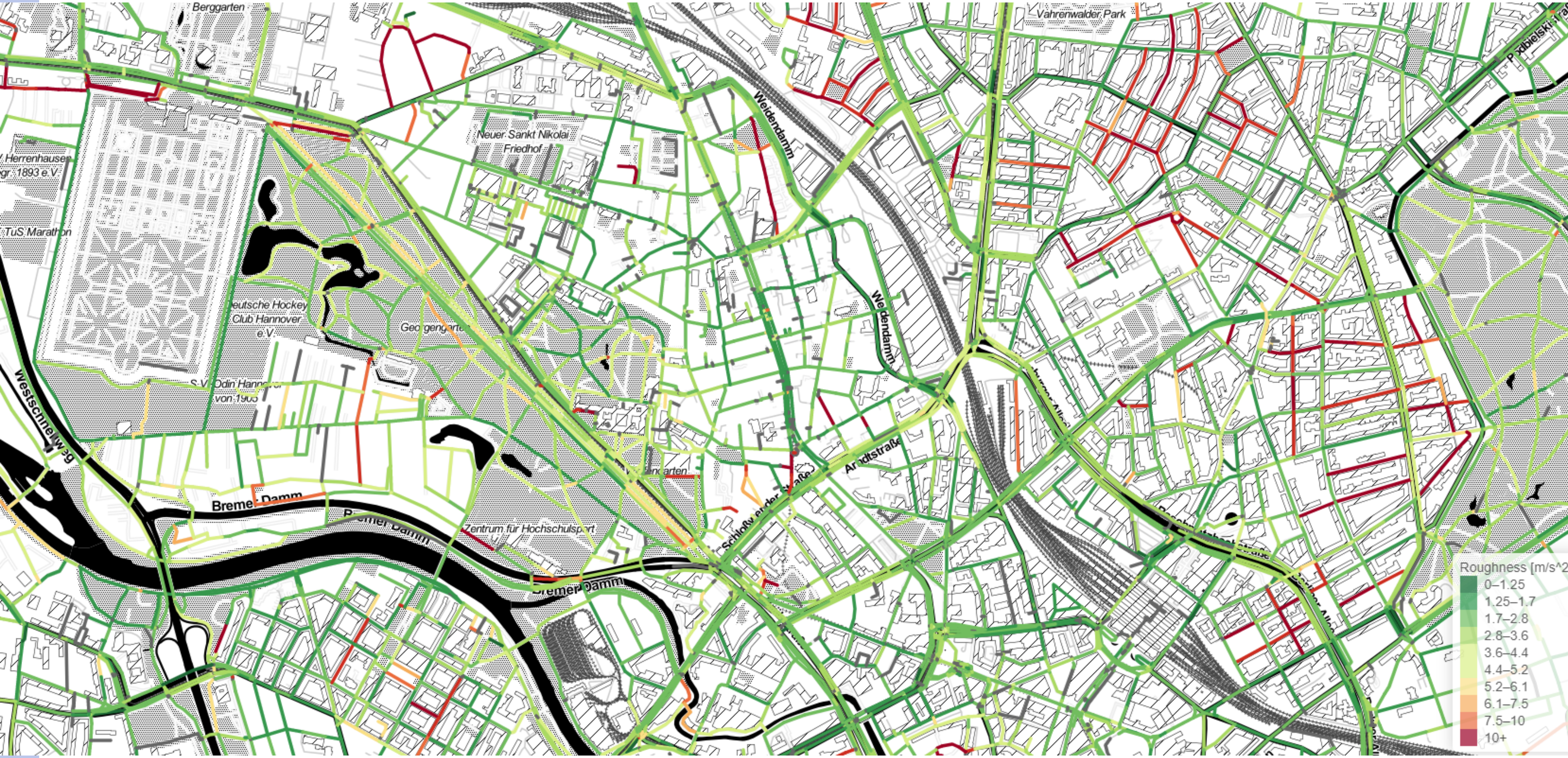
Automatic calibration through optimization

- Measurements of the same road sections should be the same for different trips
- Use road identity as a "linking structure" to match different trip data to the same roughness scale
- -> One estimated correction factor per trip



[https://www.pinterest.de/pin/749497562986798371]
[https://stock.adobe.com/de/images/a-woman-bicycle-riding-bike-cyclist-in-silhouette/241696697]

Roughness map at city scale



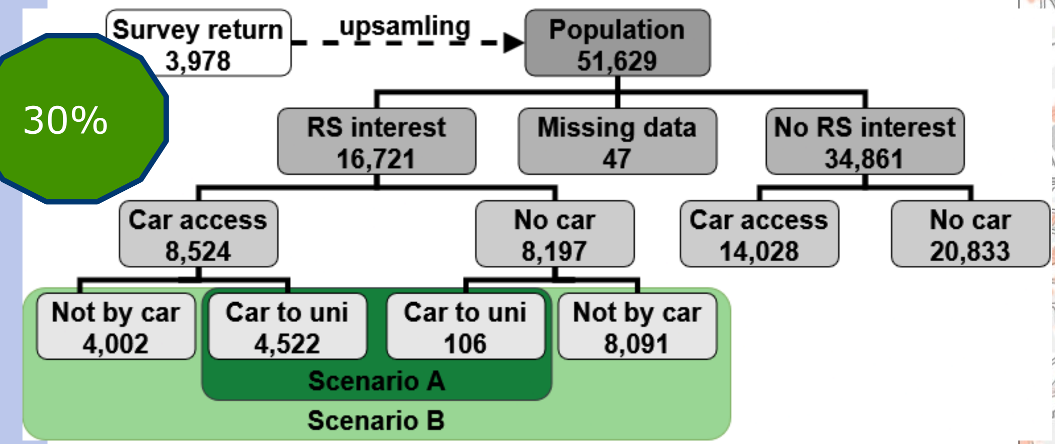
Ride-Sharing Potential at Hanover Universities

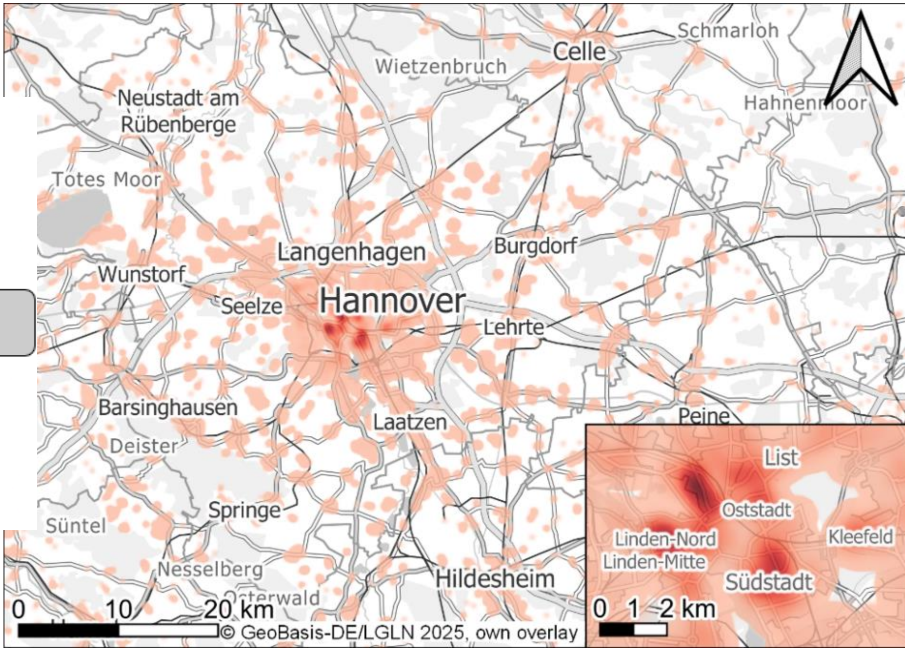
- Often: car owners drive alone
- -> Ride-sharing (car pooling) addresses low occupancy rates of cars when commuting
  - Reduction of emissions
  - Saving parking space
  - Sharing commuting costs

DiNaMO

Ride-Sharing Potential at Hanover Universities

- Extrapolation of a mobility survey at the universities
  - Definition of scenarios according to ride-sharing interest, car availability and car use
  - Geographical distribution according to known zip code and census population density
- Simulation of possible matchings by **integer optimization**
- Varying detour and seat limits

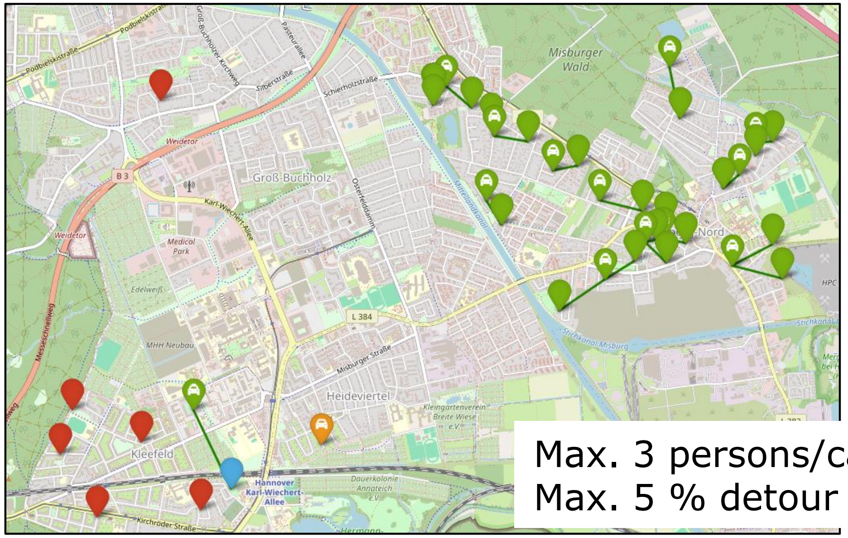




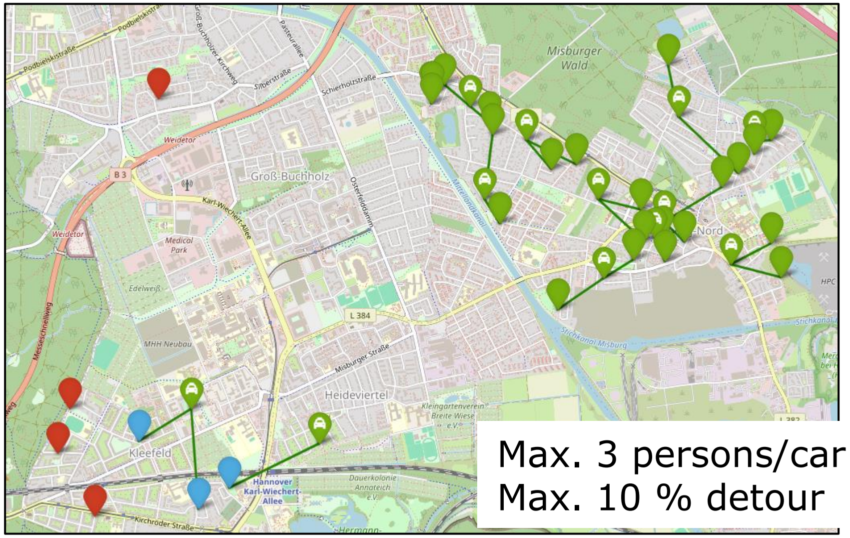
Ride-Sharing Potential at Hanover Universities

- Exemplary matching situations resulting from different detour limits
- Eastern area with many close-by car owners and passengers: very small detours
- Western area with low cars and passenger density: larger detours to be accepted

- Green: Matched car owner
  - Car icon indicates actual driver
- Blue: Matched passenger without car
- Orange: Car owner without match
- Red: No car and no match



Max. 3 persons/car
Max. 5 % detour



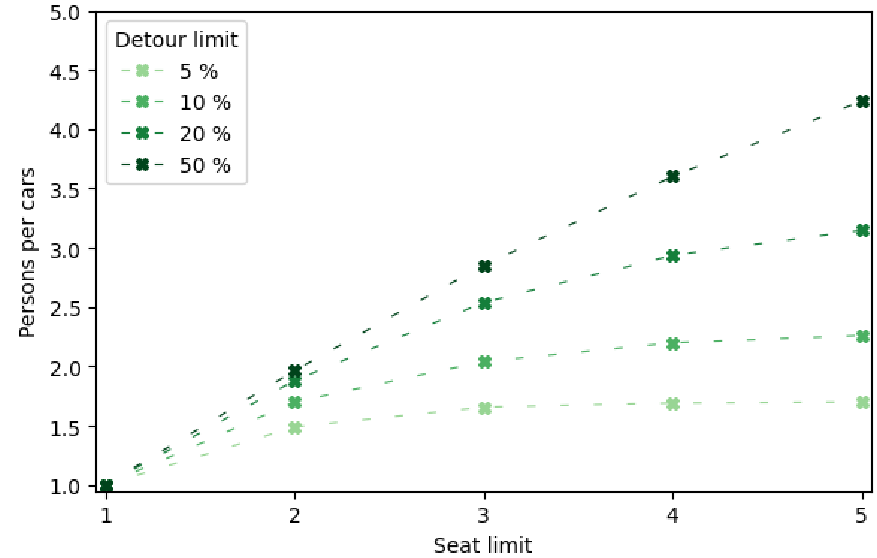
Max. 3 persons/car
Max. 10 % detour

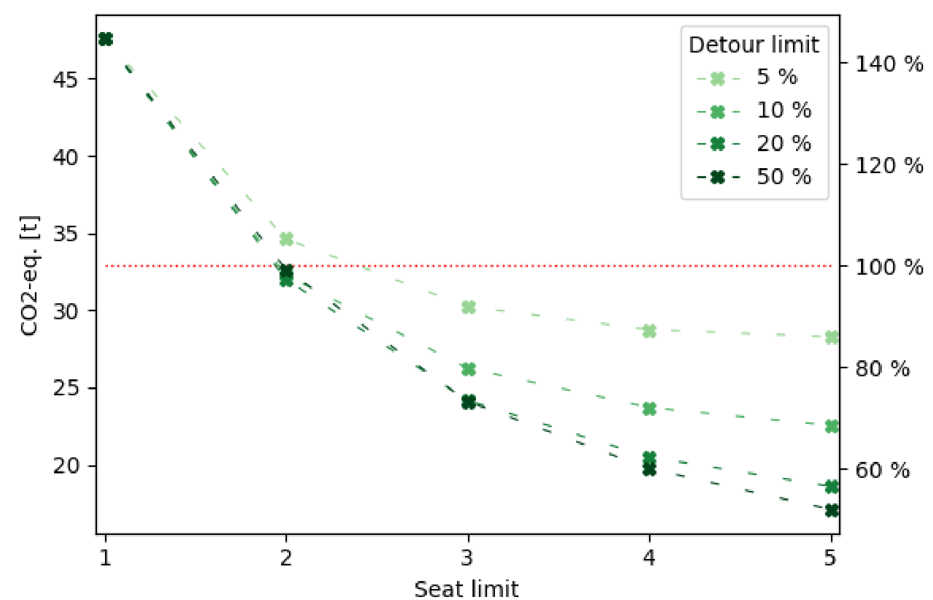
Ride-Sharing Potential at Hanover Universities

- Can enough passengers be found to increase the utilization of the vehicles despite limited detours and population?

- Does the system offer sufficient capacity to transport additional people without a car and expand their mobility options?

- Can **overall emissions be reduced** despite additional people and detours for collection?
  - Red bar: current CO2-emission

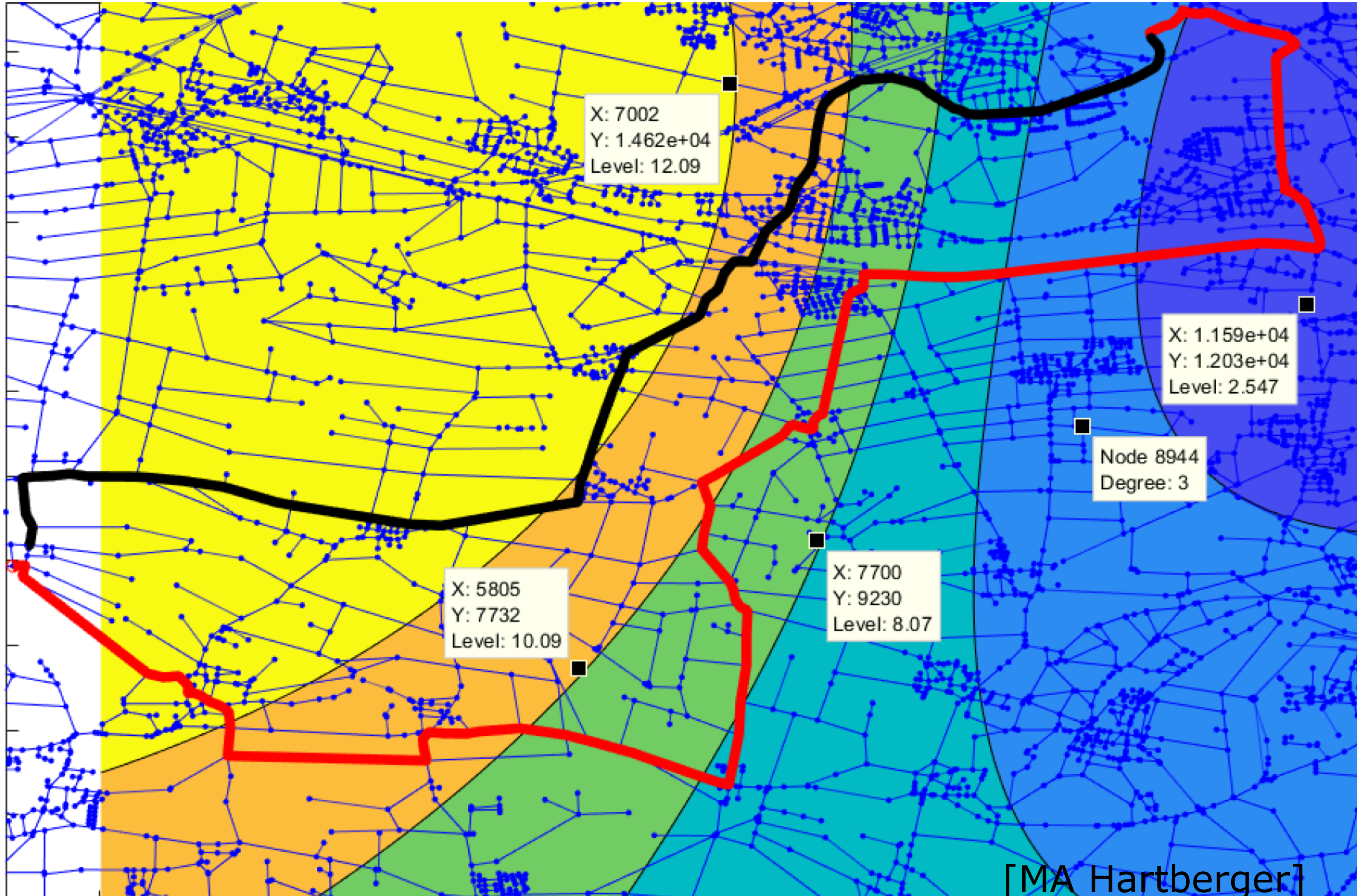




Control route-choice based by visualization of environmental conditions

Dr.-Ing. Stefan Fuest

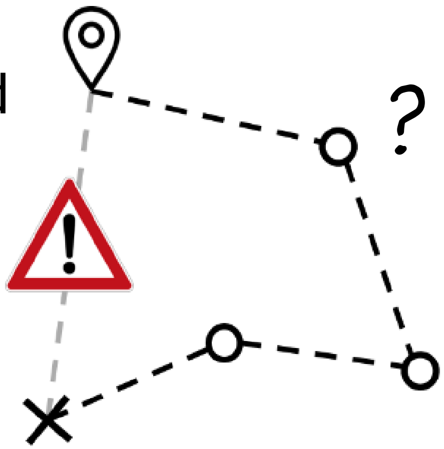
Route recommendations taking into account particulate matter pollution



[MA Hartberger]

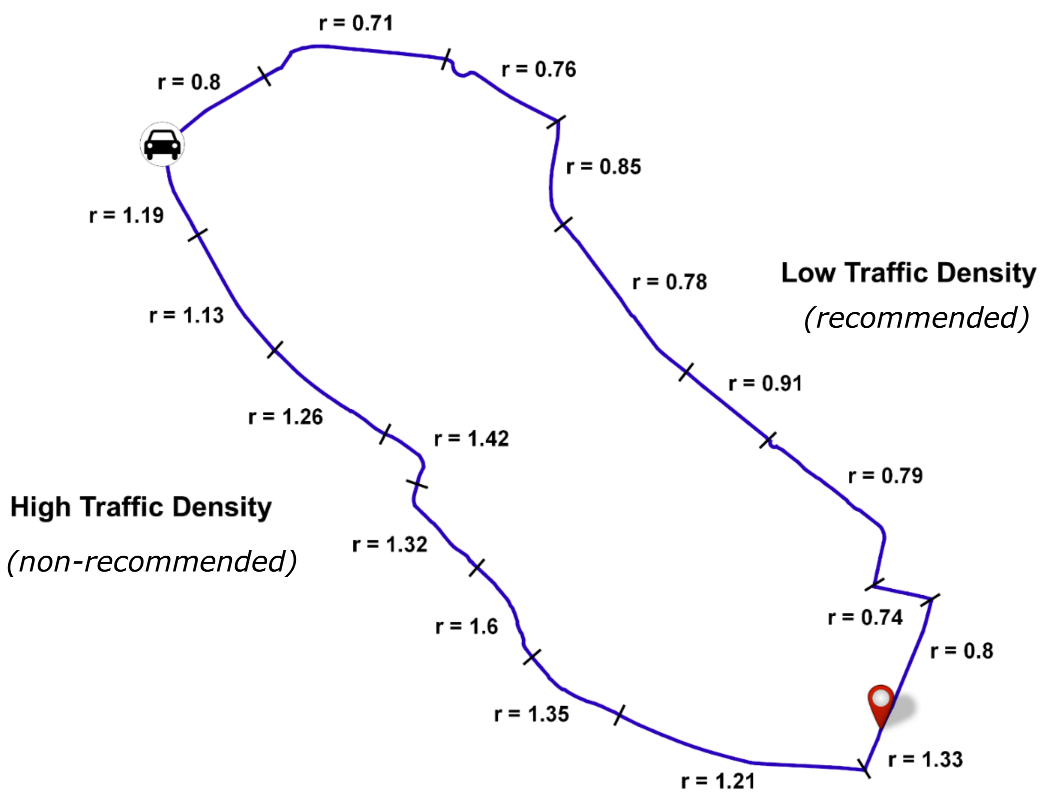
Motivation

- Increasing traffic volume leads to consequences such as congestion, air pollution, noise and accidents
- It is important to develop effective concepts for a better distribution of road traffic (avoidance of affected areas, protection of the environment and people)
- But: Drivers tend to prefer individually advantageous or familiar routes
- Research idea:
  - Encourage users to make less selfish decisions in favour of the environment ("nudging")
  - **Cartographic visualization** helps to communicate routes and traffic situations more intuitively

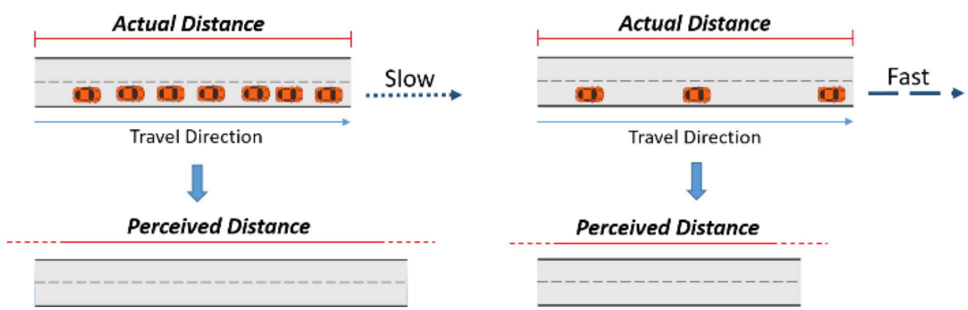


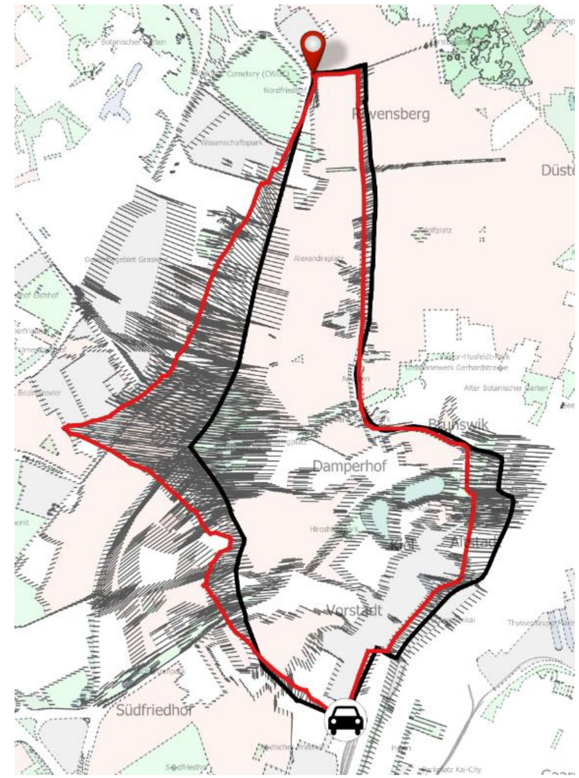
Calculation basis for graphical differences

$$r = \frac{observed\ value}{threshold}$$



Road Length Distortion





- Adjust length of individual route segments (r) according to traffic density
- Lengthen segments in dense areas
- Shorten segments in less dense areas

$$pLen\,(s) = len\,(s)\,\frac{ø\,dens\,(s) + (dens\,(s) - ø\,dens\,(s)) \cdot w}{ø\,dens\,(s)}$$

$$enlarge = \frac{pLen\,(s)}{len\,(s)}$$

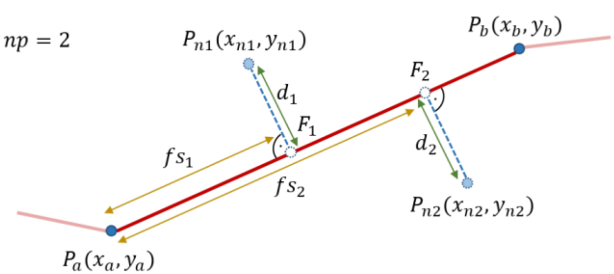
Line simplification and distortion

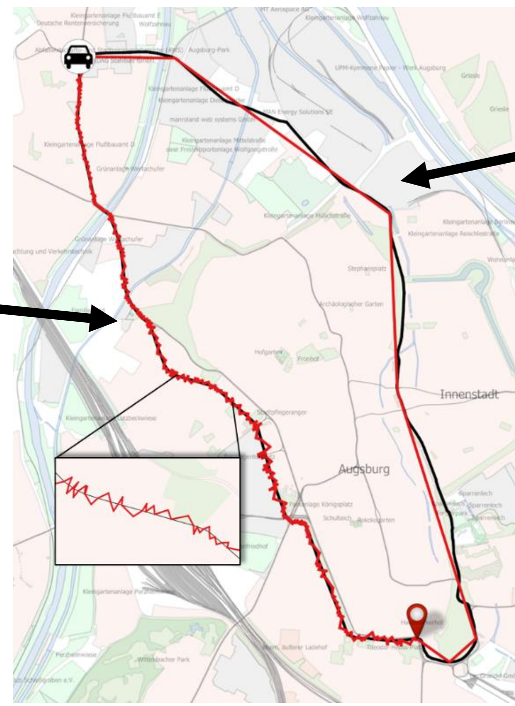
$r > 1$ Distortion

- New approach (line distortion) for high density segments
- ➢ Insert additional points to line based on traffic density

$$\boldsymbol{d} = w \cdot (length \cdot r \; - \; length)$$

with *length* = ø *length*



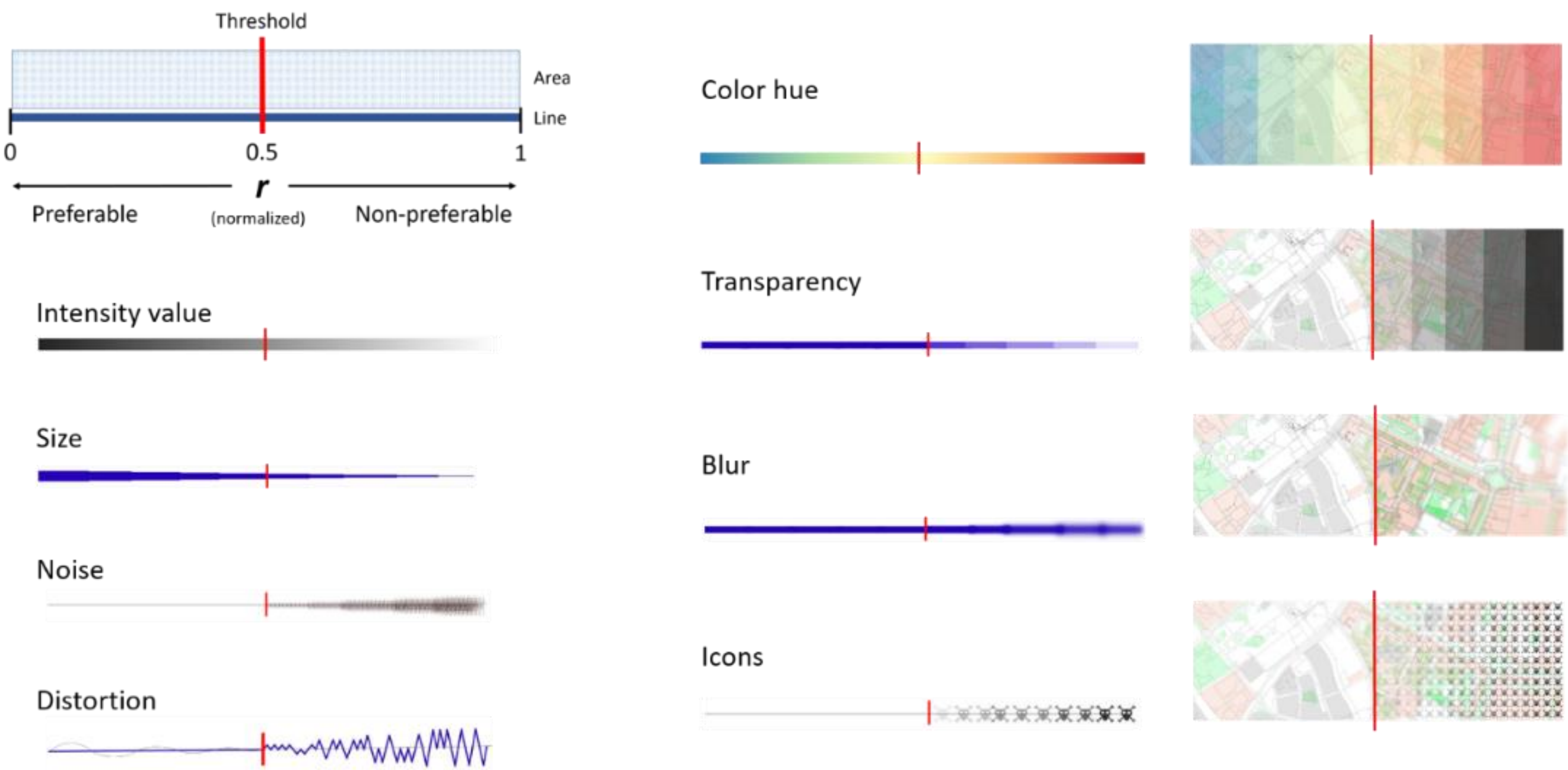


Simplification **$r < 1$**

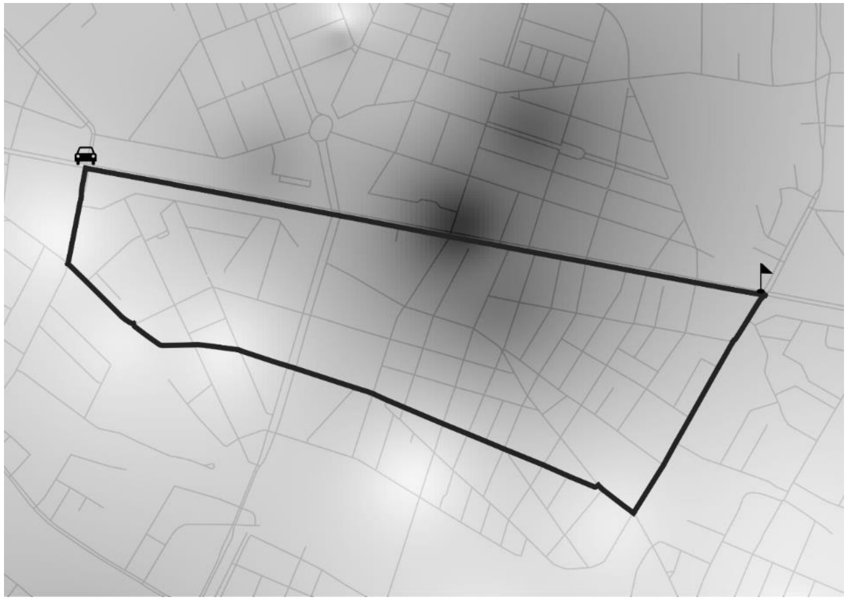
- Line simplification using Douglas-Peucker for low density segments
- Based on Douglas-Peucker Algorithm

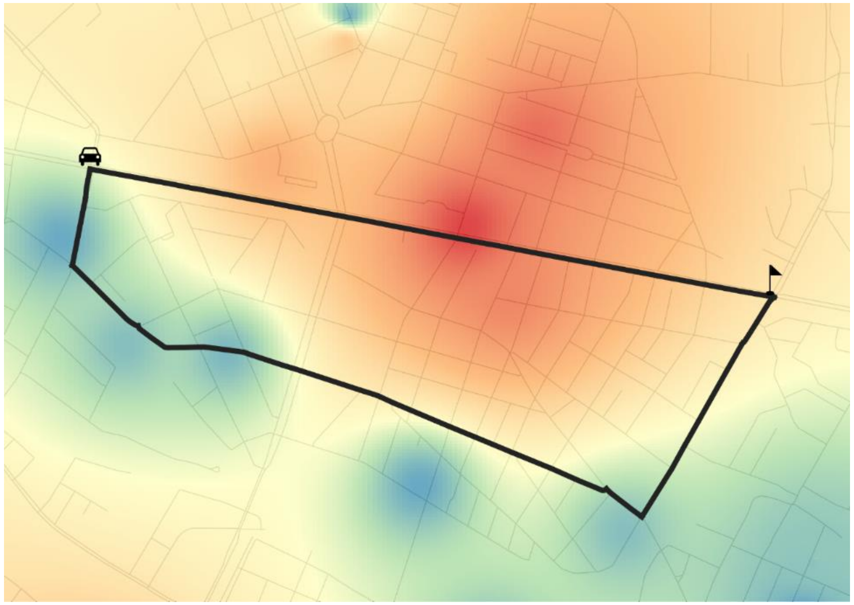
$$epsilon = dmax * (1 - r), \text{with } r < 1$$

Graphical differences of lines (left) and areas (right)

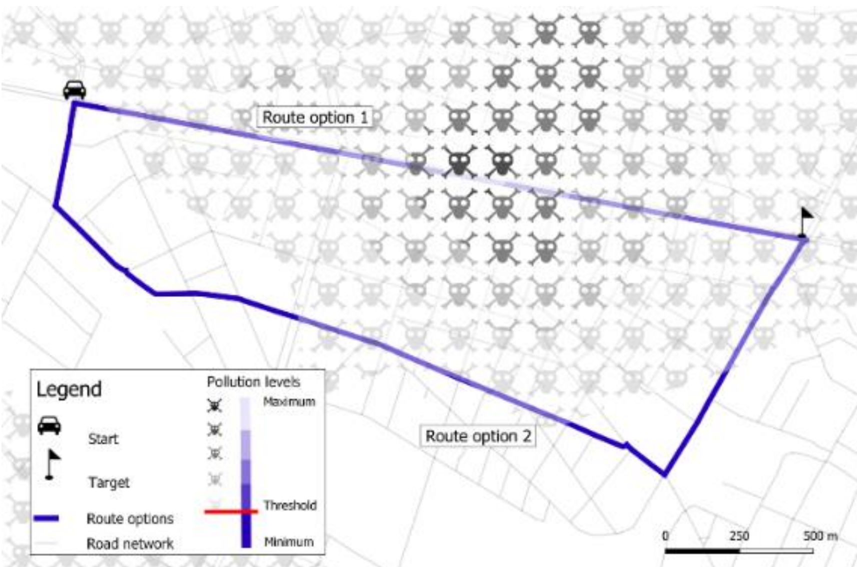


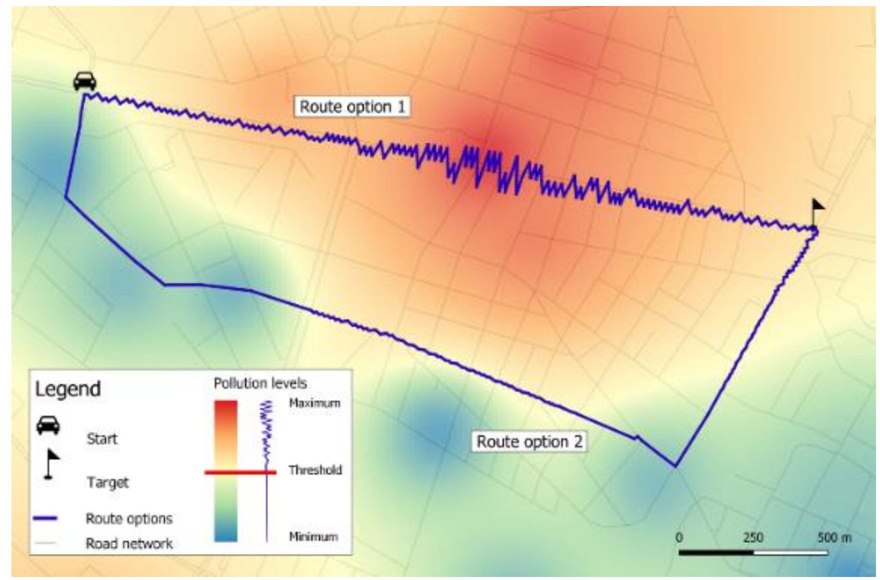
Modification of areal objects





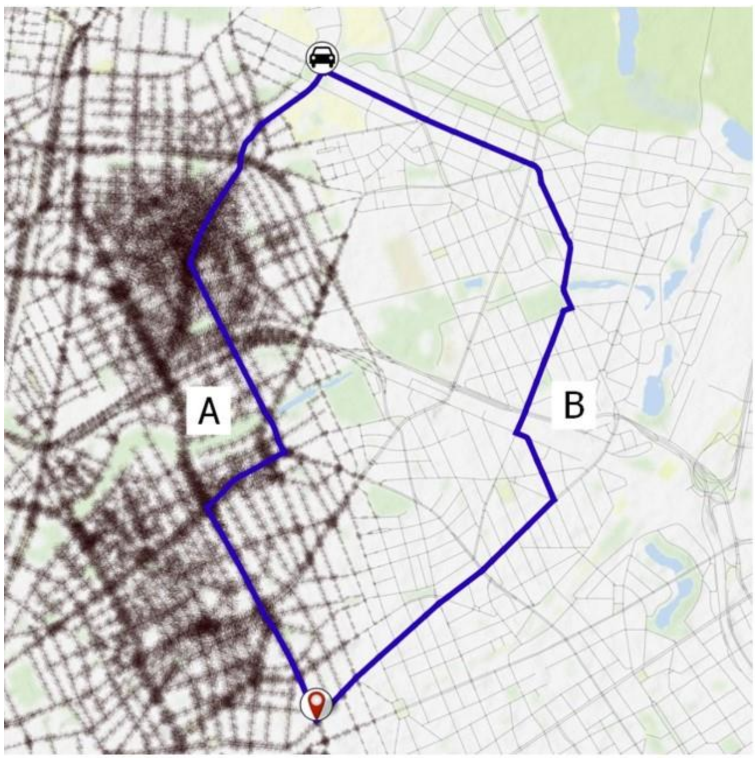
Combined modification (Area + Line)

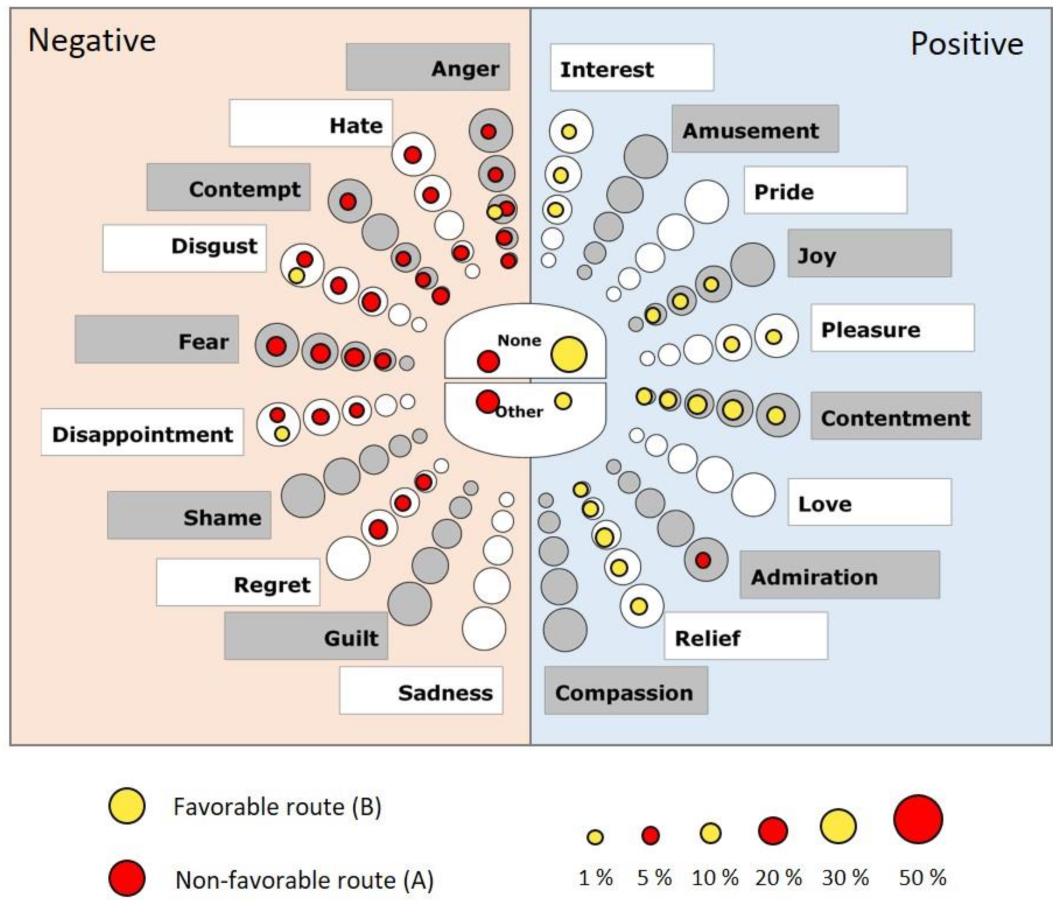




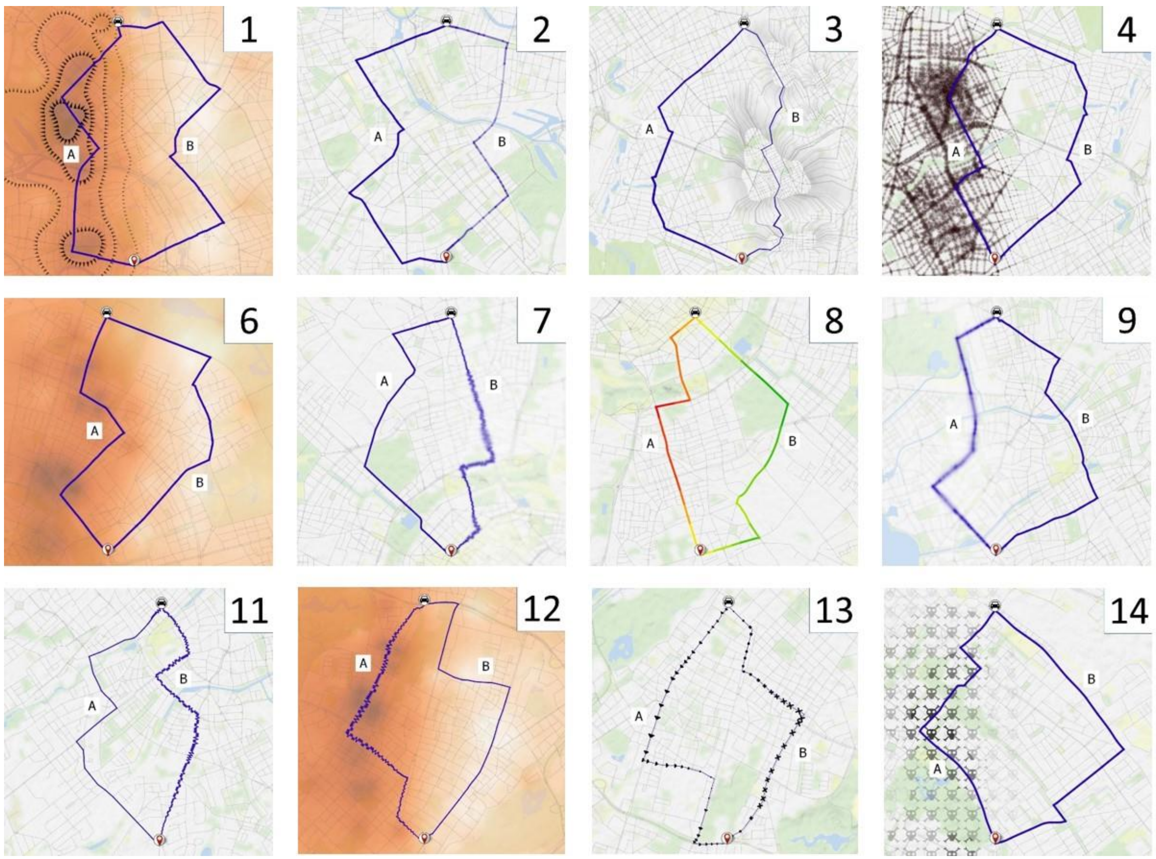
Percentages of felt emotions (*Scribble* variant in *traffic* scenario)

- Investigate the emotions that the map-reader feels when interacting with the map representations
- Emotional responses to map symbols are expected to affect the traveler's route choice decision





Visualization variants



1 Color value + Spikes
2 Transparency
3 Deformation
4 Scribble
5 Spikes
6 Color value (Area)
7 Distortion + Blur
8 Color hue (Line)
9 Blur
10 Color value + Size
11 Distortion
12 Color value + Distortion
13 Icons (Line)
14 Icons (Area)

Route choice preferences for modified maps in percent

Summary

Summary

- Principles of sustainable mobility
  - **Reduce**: e.g. autonomous driving (Robotaxi), improved logistics
  - **Shift**: e.g. local delivery with cargo bikes, active mobility (cycling, walking), "sharing‟, mobility budgets
  - **Avoid**: e.g. 15-min-city

- Available sensor technology and data sets allow a detailed image (spatio-temporal) of our environment
- Investigate tasks and problems in the field of mobility and offer new solutions
- Optimization and reduction of traffic is essential for achieving climate targets; together with balancing resources
- ***Geoinformatics has a lot to offer!***
- ***Technical and societal task!***

ACM Journals

CALL FOR PAPERS

ACM Transactions on Spatial Algorithms and Systems
Special Issue on Urban Mobility

Guest Editors
Latifa Oukhellou, Université Gustave Eiffel, France
Monika Sester, Leibniz University Hannover, Germany
Stephan Winter, The University of Melbourne

The special issue on Urban Mobility calls for computational research on the massive geospatial datasets related to urban mobility with a focus on optimizing individual mobility modes, exploring modal shifts towards more sustainable modes, assessing urban mobility demand based on sustainability principles, and developing decision support tools and strategies to support sustainable urban mobility.

Click here for the full Call for Papers and submission instructions.

Important Dates
March 1, 2025: System opens for submissions
May 31, 2025: Submissions of full-length papers
July 31, 2025: Notification of initial reviews
August 31, 2025: Submission of revisions
September 30, 2025: Notification of final reviews
October 15, 2025: Submission of final camera-ready manuscripts
December 31, 2025: Expected publication