UNIVERSITÄT BONN

VGIscience

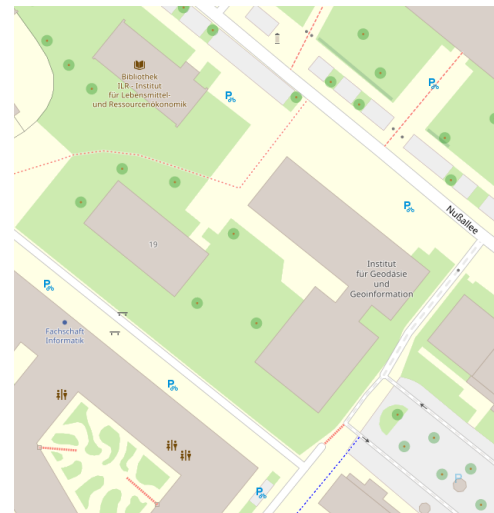# Analyse nutzergenerierter Trajektorien von Fahrradfahrern

GeoIT Round Table NRW
29th March 2023

Jan-Henrik Haunert

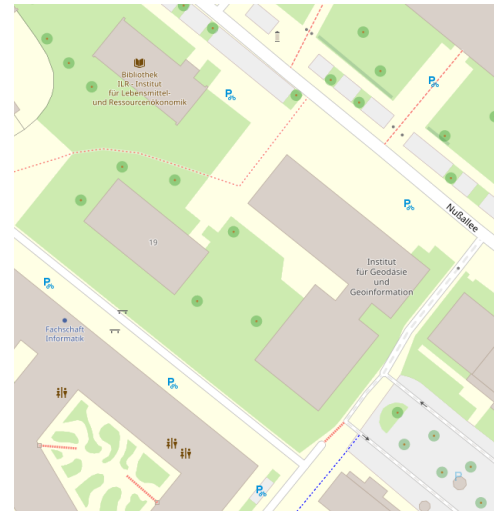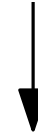# Volunteered Geographic Information

OpenStreetMap.org

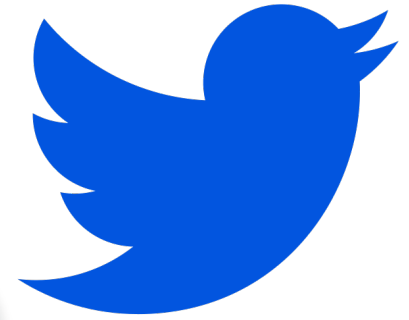# Volunteered Geographic Information
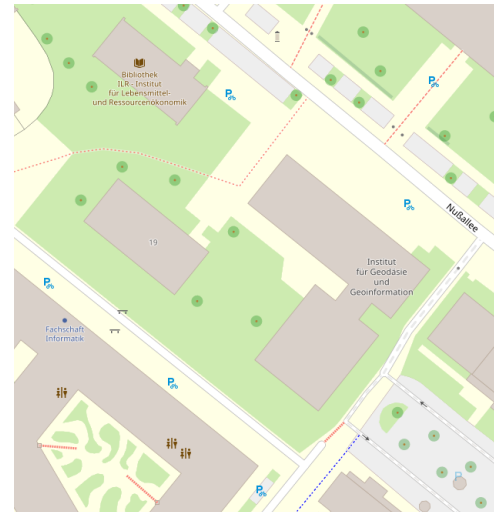

flickr.com

OpenStreetMap.org

Volunteered Geographic Information

flickr.com
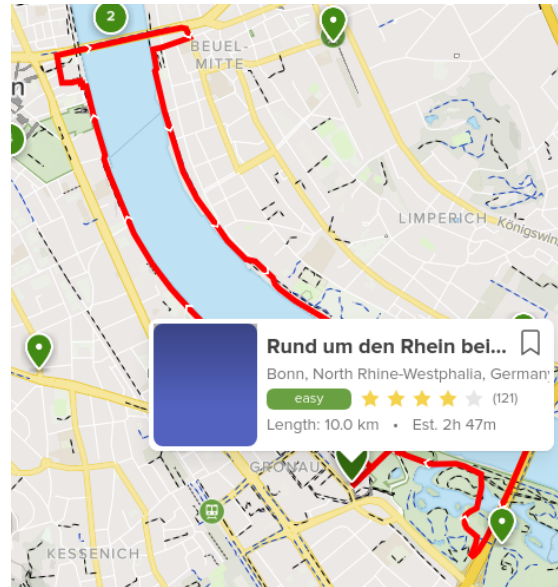
OpenStreetMap.org

Twitter.com

The whole building collapsed!

Volunteered Geographic Information

flickr.com

GPSies.com
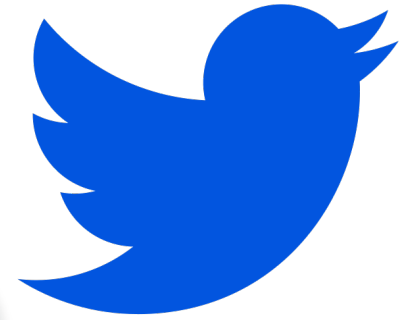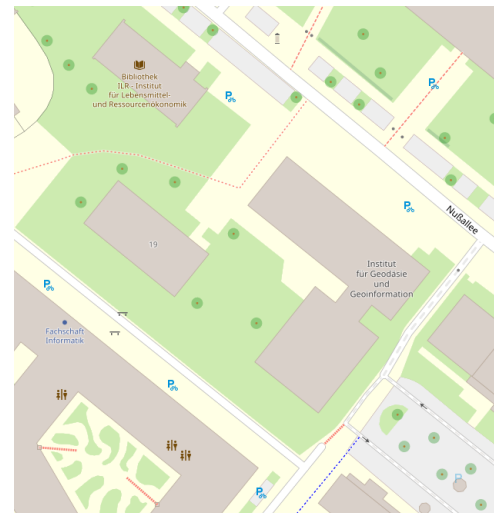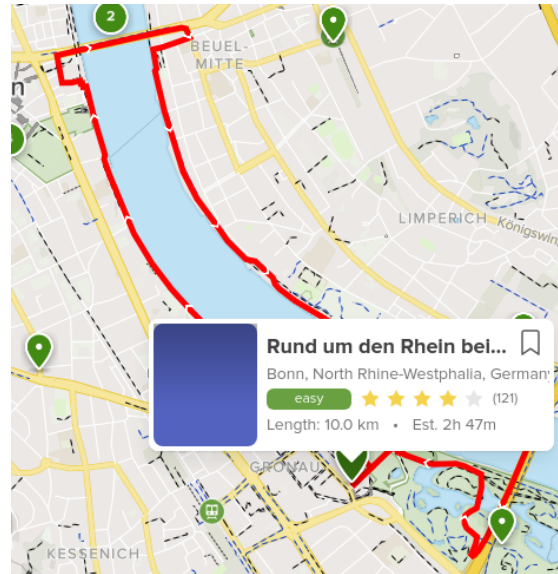
AllTrails.com

OpenStreetMap.org

Twitter.com

Volunteered Geographic Information

flickr.com

AllTrails.com

GPSies.com

OpenStreetMap.org

Twitter.com

Rund um den Rhein bei...
Bonn, North Rhine-Westphalia, Germany
easy ★★★★☆ (121)
Length: 10.0 km · Est. 2h 47m

Example User XY
@xy
The whole building collapsed!
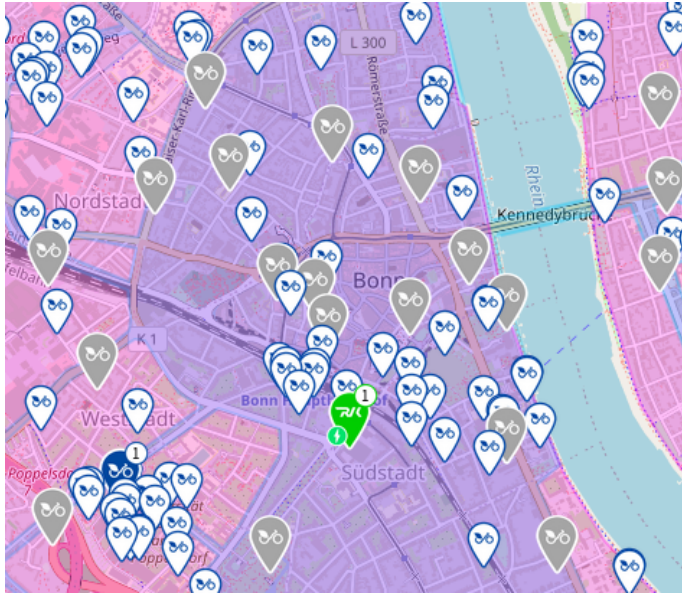2:23 PM · Jun 11, 2023 · Twitter for iPhone
57 Retweets 12 Quote Tweets
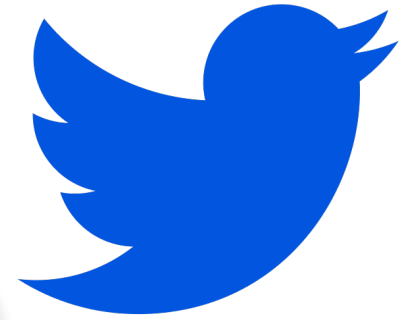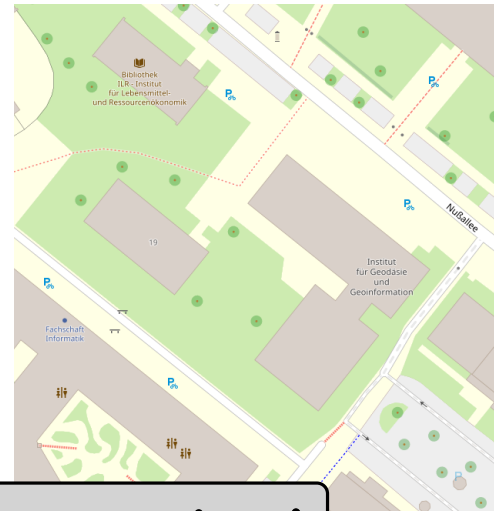
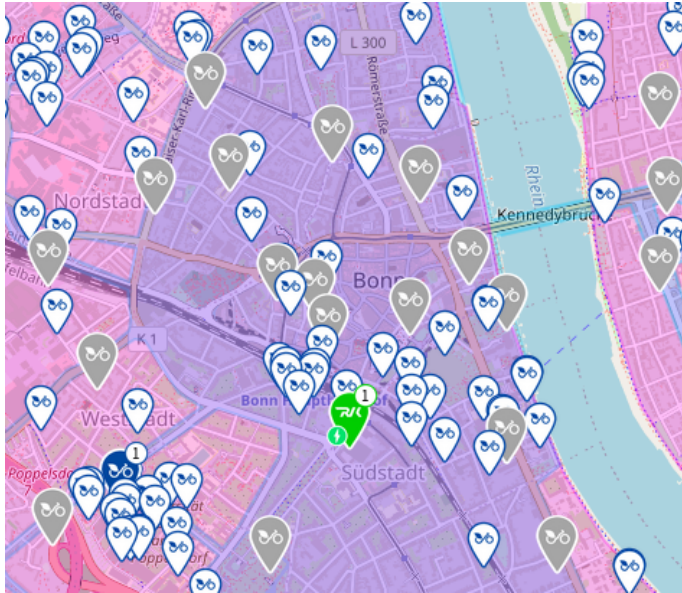high data heterogeneity!

VGI Trajectory Data

[1] www.nextbike.de/de/bonn

[2] www.bonn.de/radverkehr

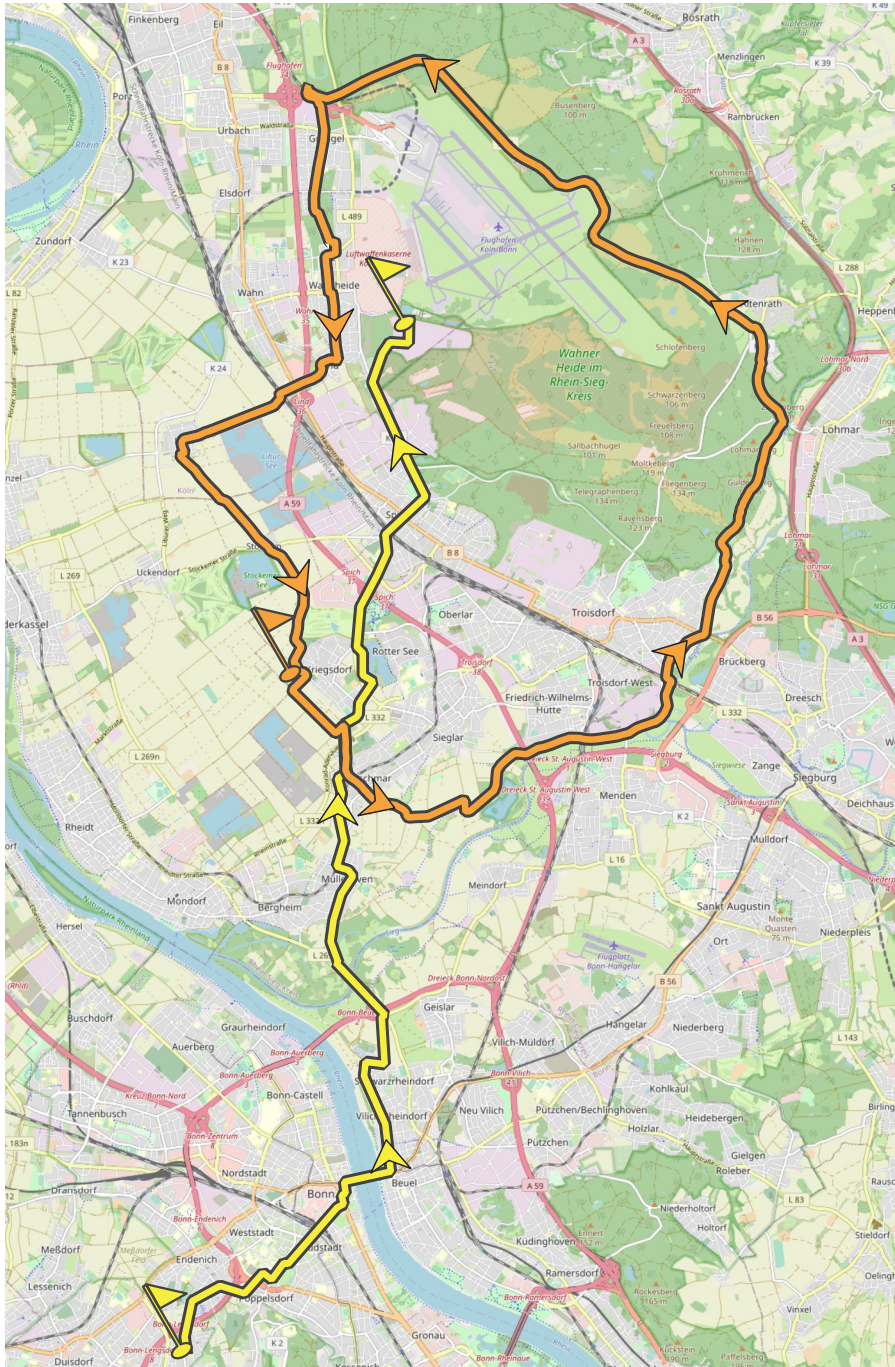# VGI Trajectory Data

[1] www.nextbike.de/de/bonn

[2] www.bonn.de/radverkehr

+ data resembles user's view
"from user for user"

VGI Trajectory Data

+   data resembles user's view
   "from user for user"

-   **data heterogeneity**

   -   user intention unknown

   -   data quality hard to assess
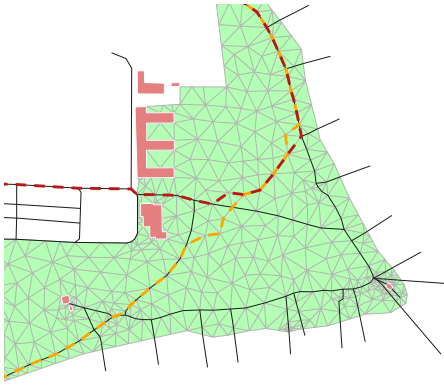
-   privacy concerns

My Work

Preprocessing	Analysis	Visualization

My Work

Preprocessing	Analysis	Visualization

Map Matching

My Work

Preprocessing	Analysis	Visualization

Map Matching

Privacy

My Work

Preprocessing	Analysis	Visualization

Map Matching

Privacy

Inferring Routing Preferences

My Work

Preprocessing	Analysis	Visualization

Map Matching

Privacy

Inferring Routing Preferences

Off-screen Evolution

My Work

Preprocessing	Analysis	Visualization

Preprocessing
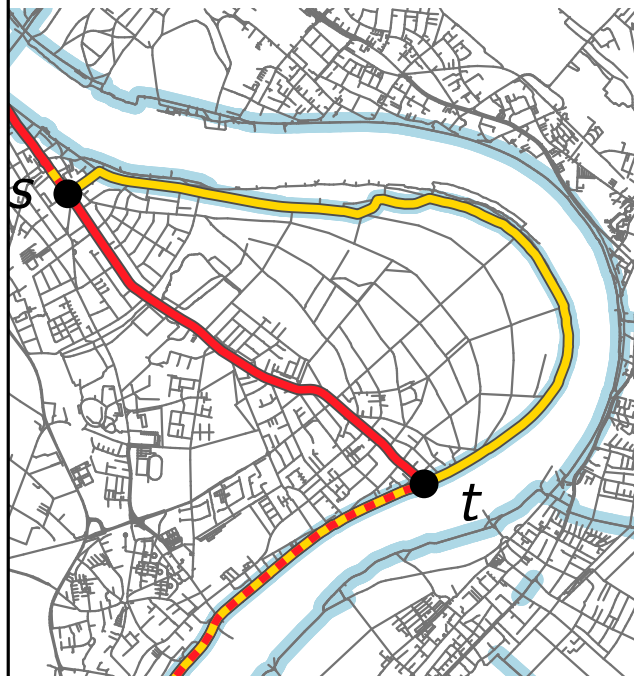
Map Matching

Privacy

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Off-screen Evolution

Travel-Time Maps

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Travel-Time Maps
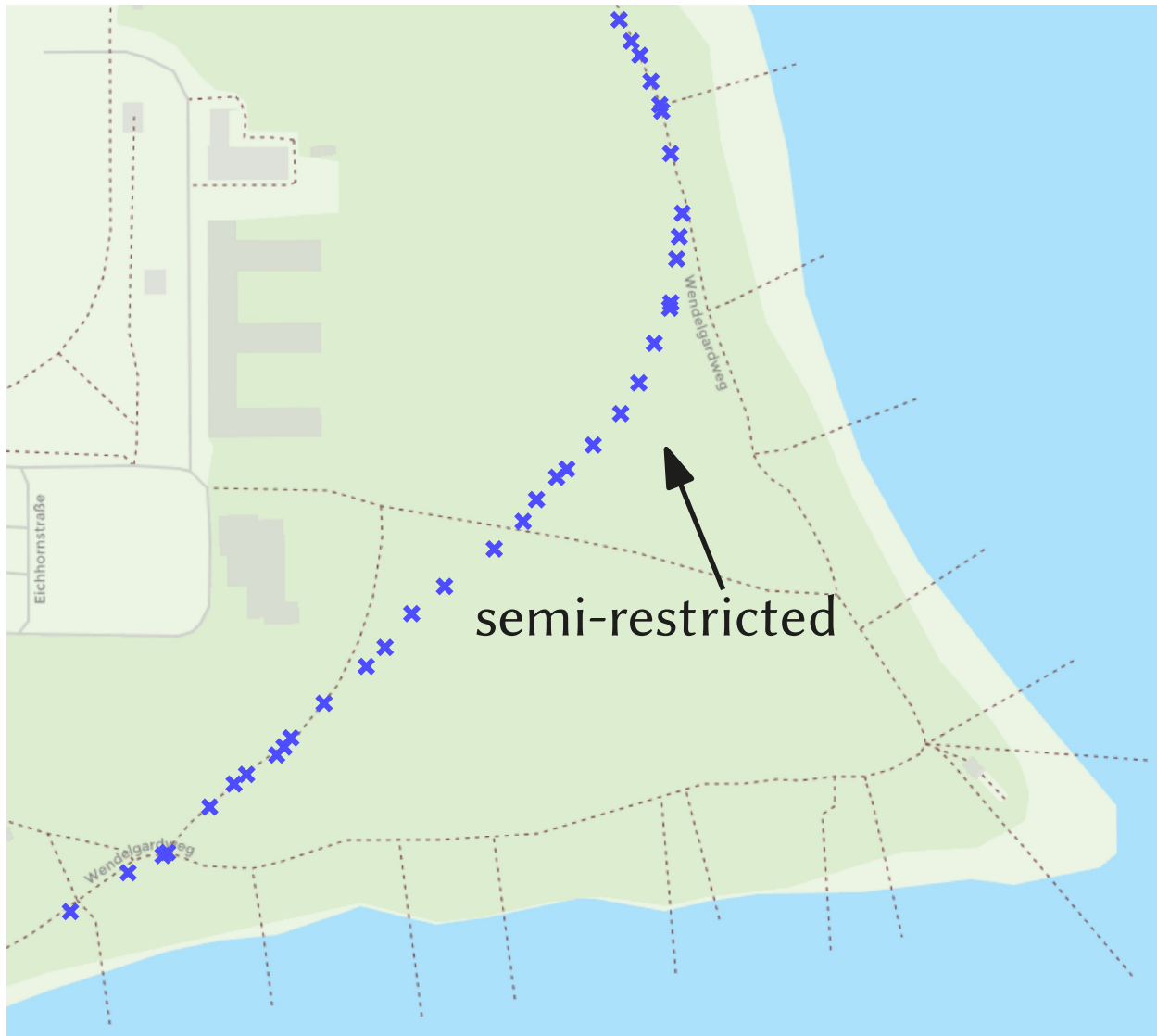
5 - 1
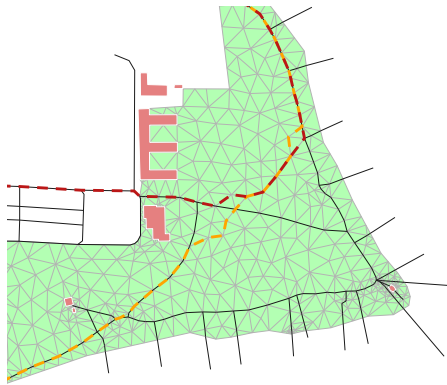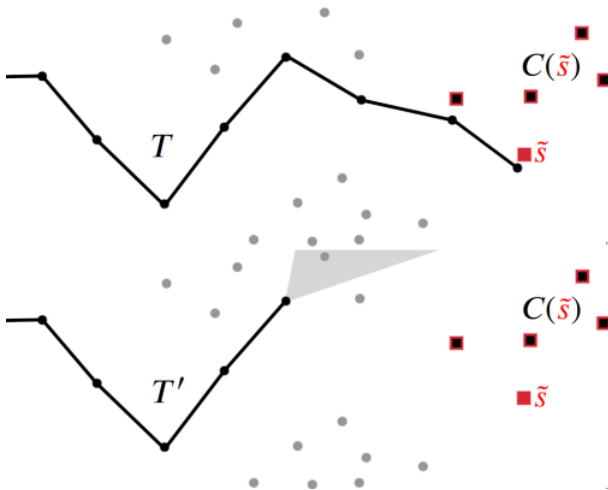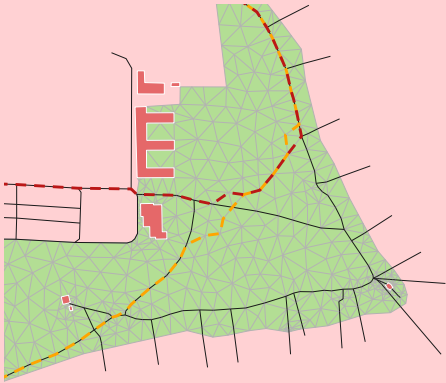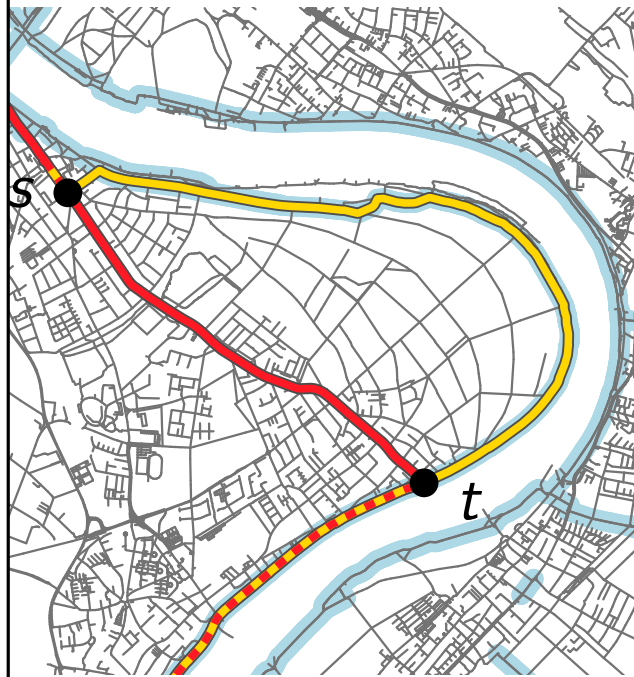
Map Matching

Map Matching

Use-cases for
matched trajectories:

- comparison of trajectories

- lower storage space
  - fewer points
  - efficient index
    structures (Funke et al.,
    2019)

- inferring routing
  preferences

- …

Map Matching

semi-restricted

Use-cases for matched trajectories:

- comparison of trajectories

- lower storage space
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  - efficient index structures (Funke et al., 2019)

- inferring routing preferences

- …

Map Matching

traditional approaches fail for unrestricted movement patterns

Use-cases for matched trajectories:

- comparison of trajectories

- lower storage space
  - fewer points
  - efficient index structures (Funke et al., 2019)

- inferring routing preferences

- ...

Map Matching

matching for incomplete network
data (Haunert and Budig, 2012)

Use-cases for
matched trajectories:

- comparison of trajectories

- lower storage space
  – fewer points
  – efficient index
    structures (Funke et al.,
    2019)

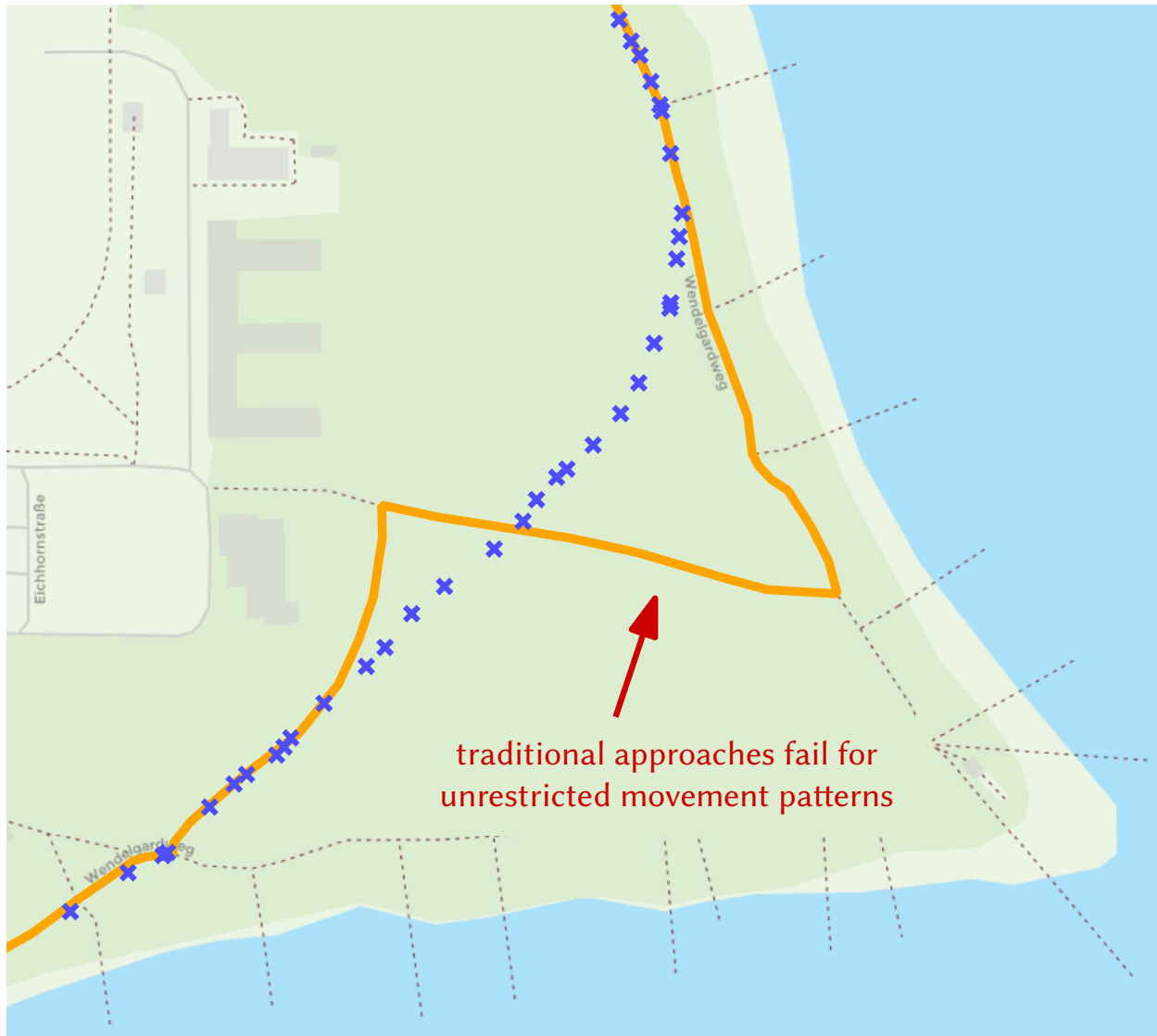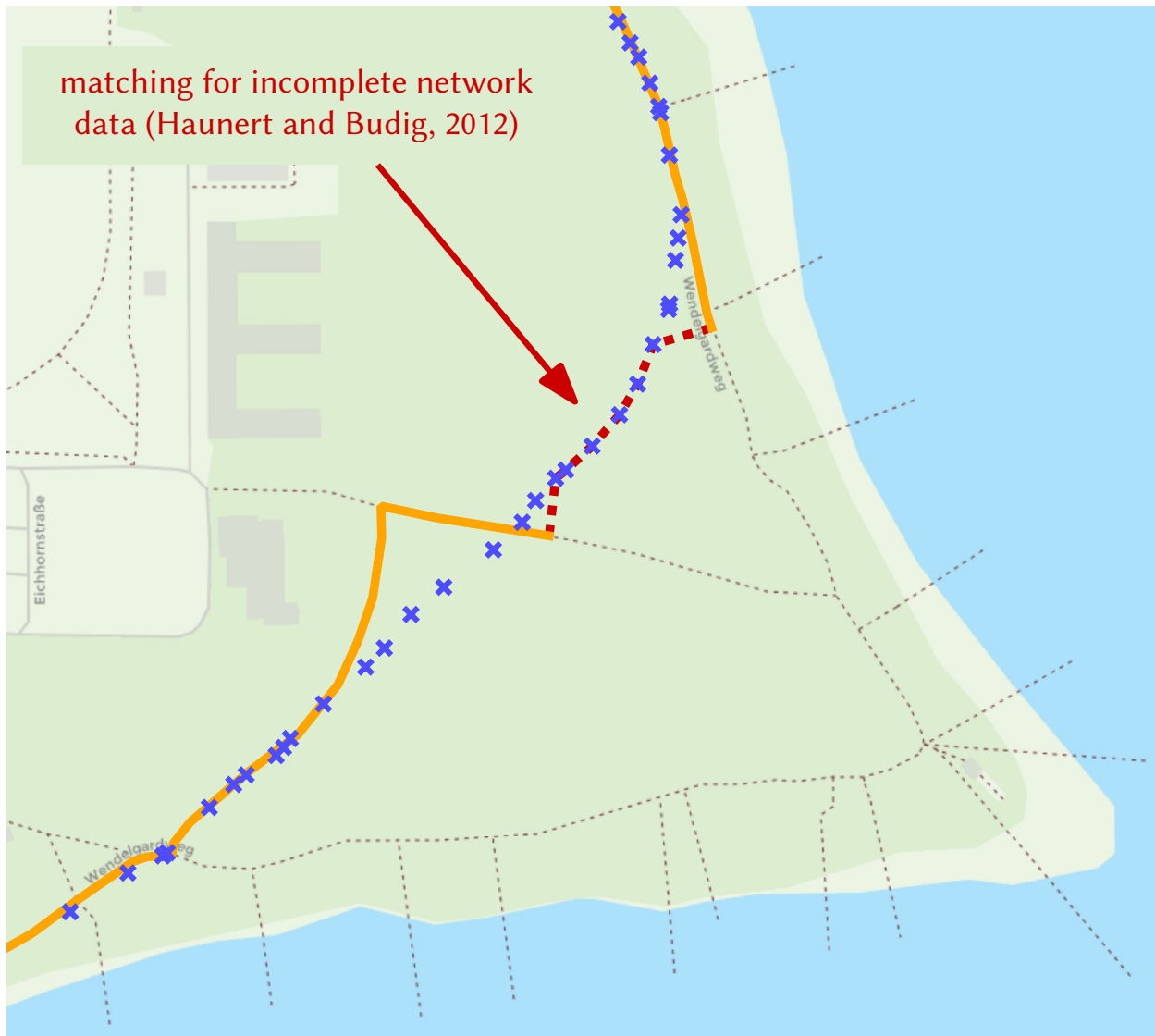- inferring routing
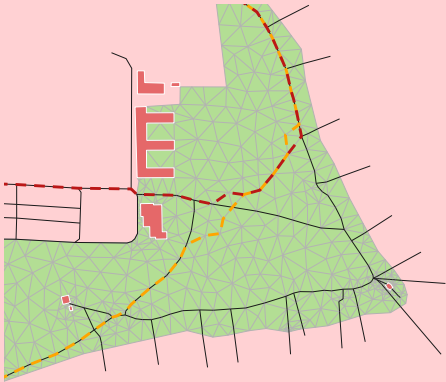 preferences

- …

Map Matching

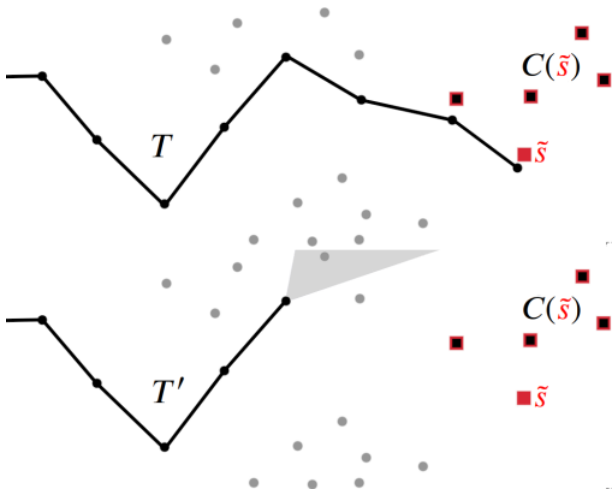Use-cases for matched trajectories:

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Map Matching

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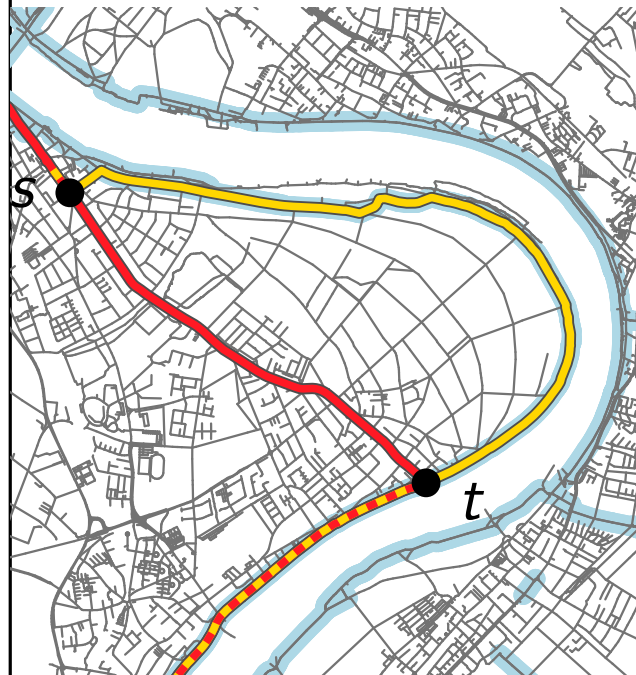
- …

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Travel-Time Maps

My Work

Preprocessing

Map Matching

Privacy

Analysis

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Travel-Time Maps

Routing Preferences

- What can we learn from **sparse sets** of trajectories, e.g., a few trajectories recorded by a single user or group of users?

road/path

cyclist 1

cyclist 2

Routing Preferences

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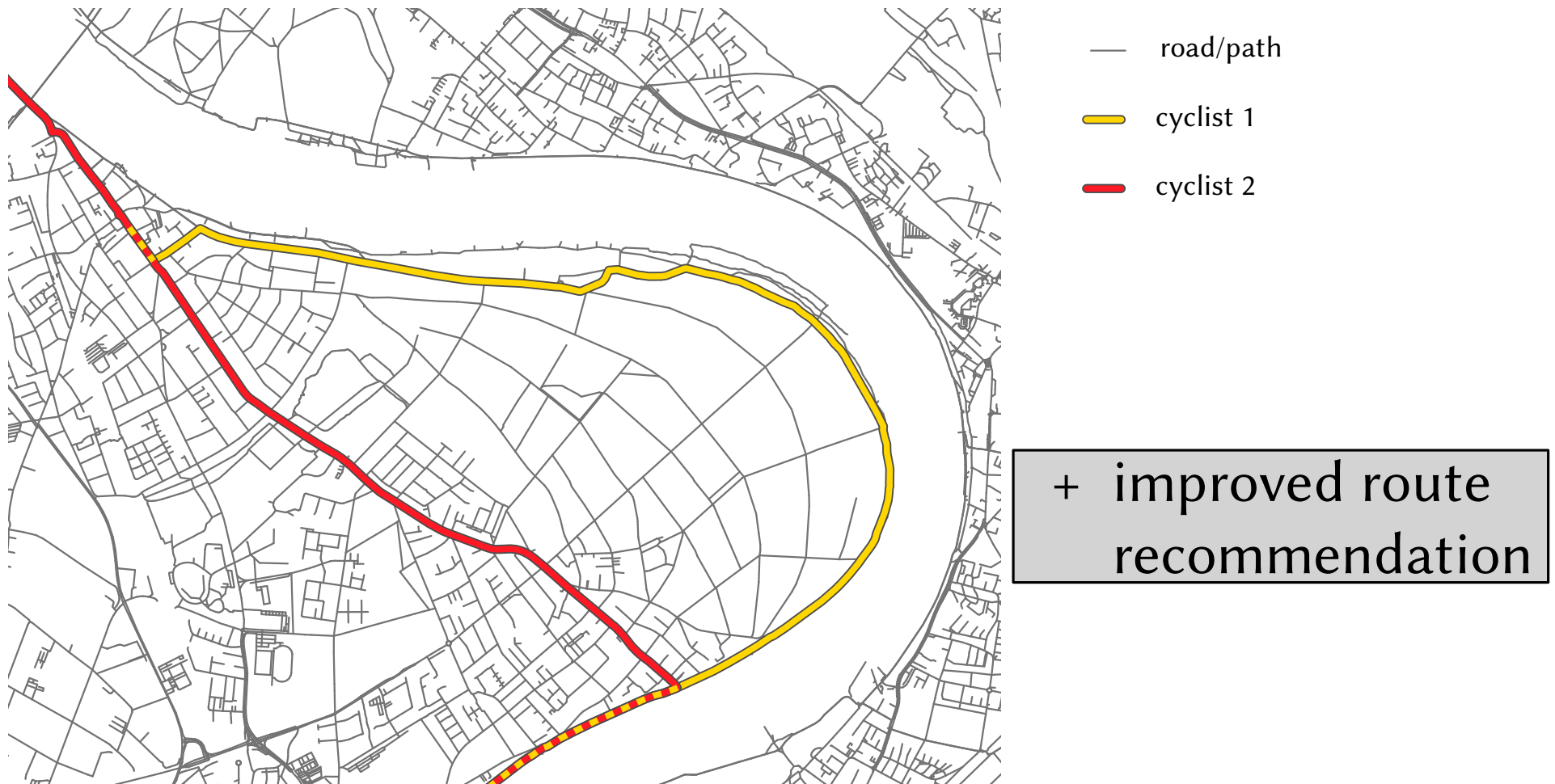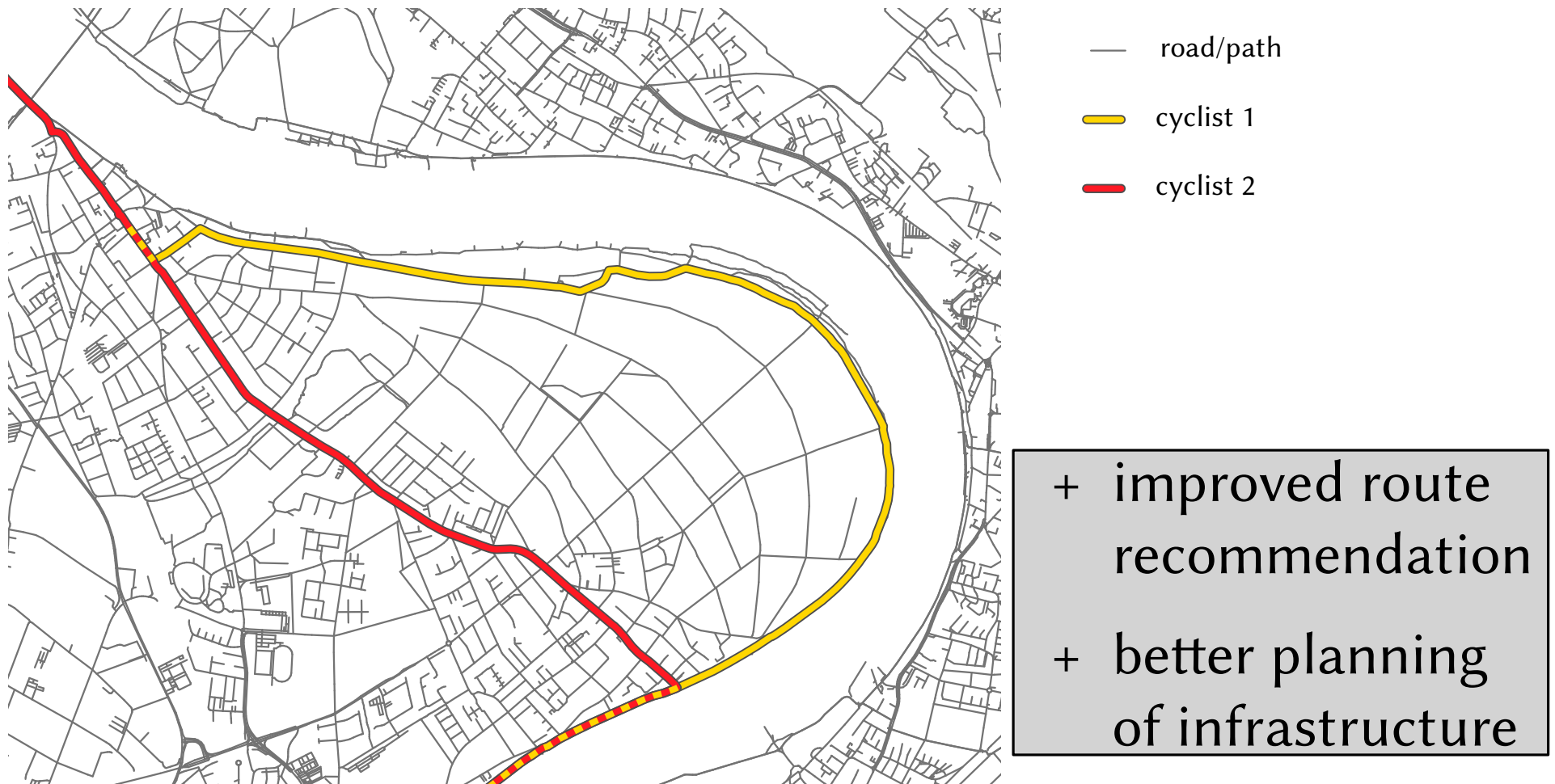
+ improved route recommendation

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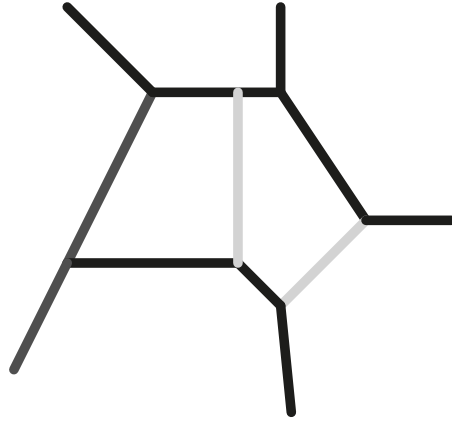

road/path
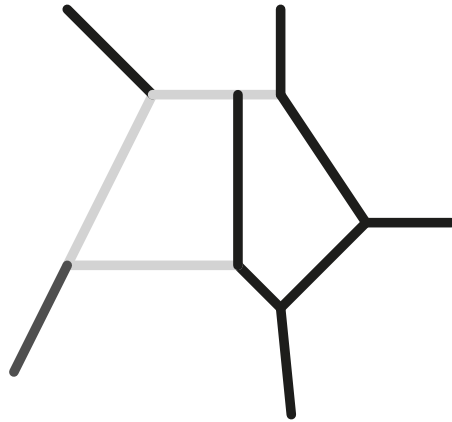
cyclist 1

cyclist 2

+ improved route recommendation

+ better planning of infrastructure

Bicriteria Preference Model

Influence factors

w_1

w_2

Bicriteria Preference Model

Influence factors

w_1 (2D geom. dist.)

w_2 (climb up)

Bicriteria Preference Model

Influence factors

Personalized weighting

w_1 (2D geom. dist.)

$w_\alpha = (1 - \alpha) \cdot w_1 + \alpha \cdot w_2$
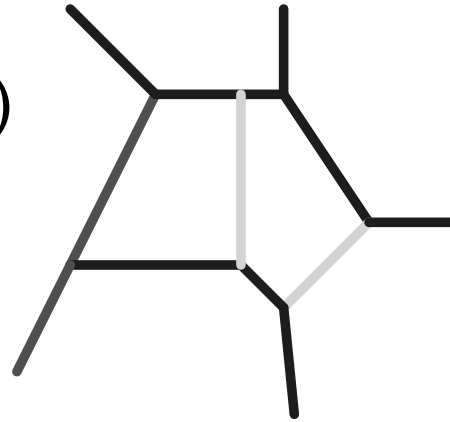
w_2 (climb up)

α-**optimal path**
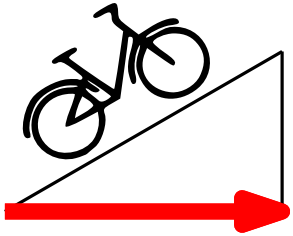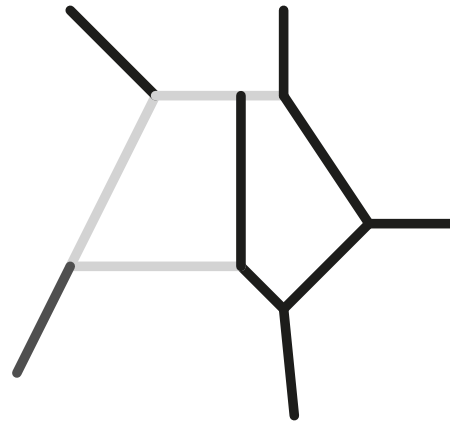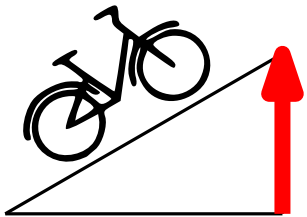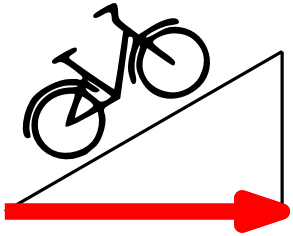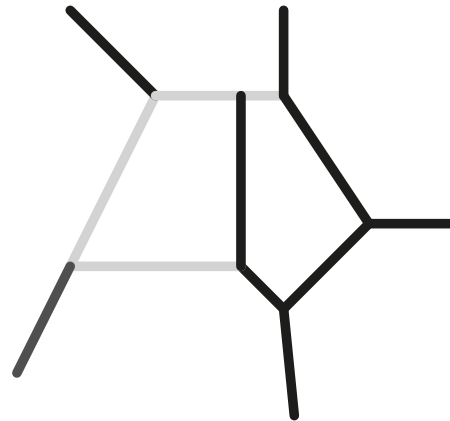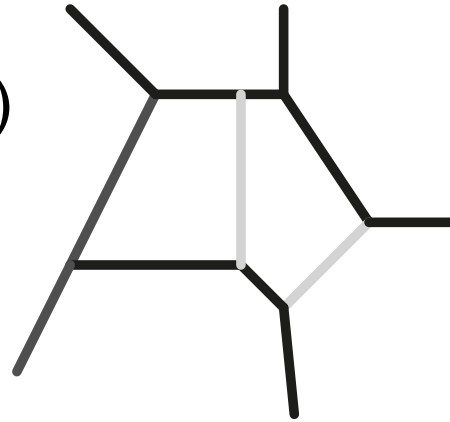
Bicriteria Preference Model

Influence factors
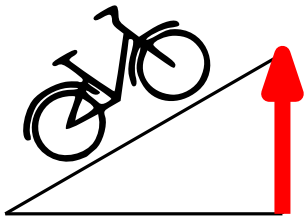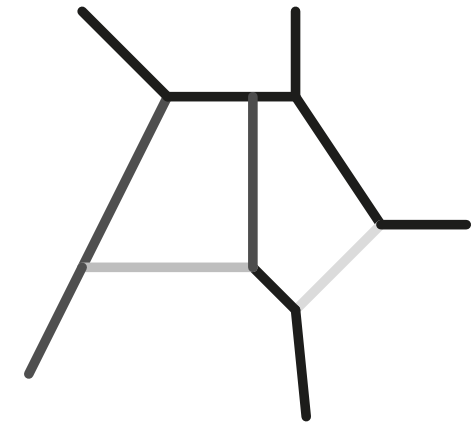
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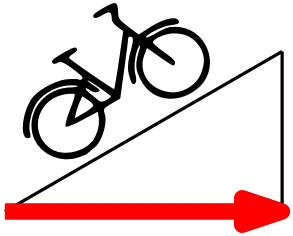
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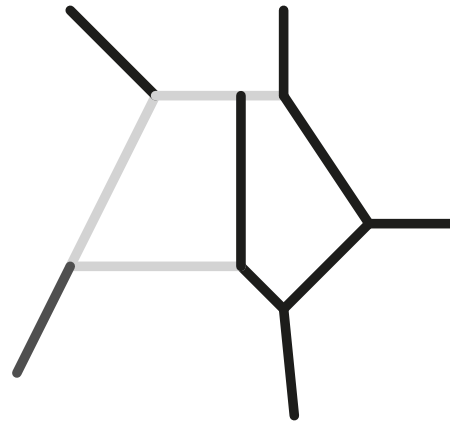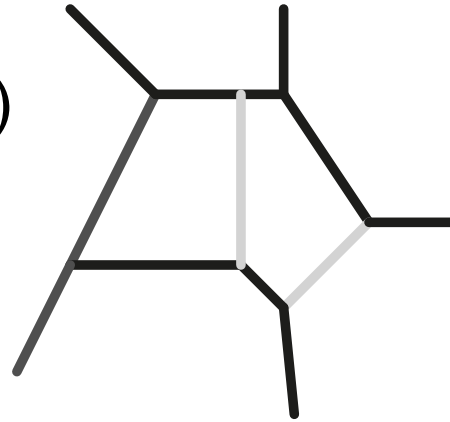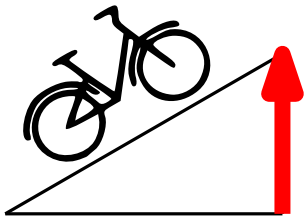
Personalized weighting

$$w_\alpha = (1 - \boxed{\alpha}) \cdot w_1 + \boxed{\alpha} \cdot w_2$$
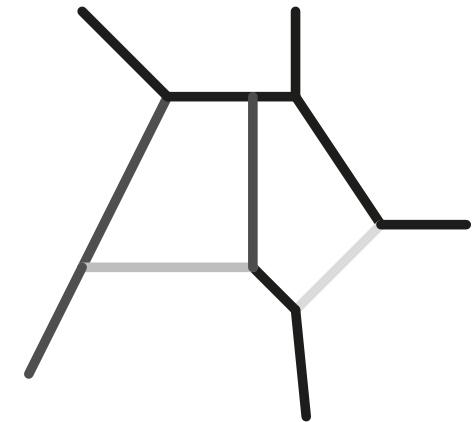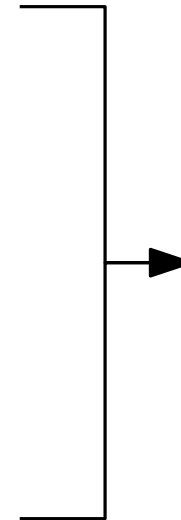
α-**optimal path**

How can we learn the parametric
weight $\boxed{\alpha}$ from a given trajectory?

Milestone Segmentation
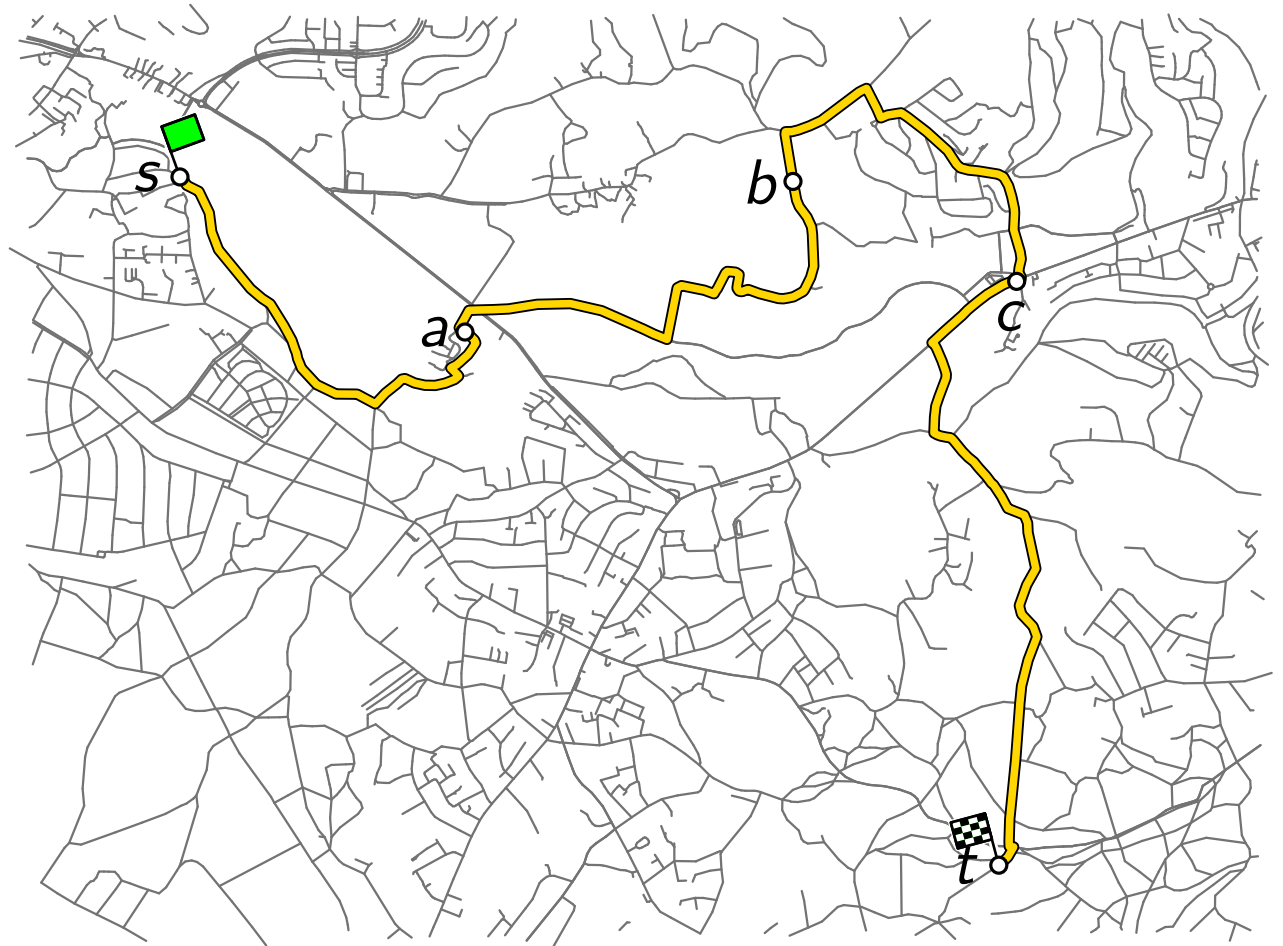
segment the trajectory into α-optimal subpaths

Milestone Segmentation

segment the trajectory into α-optimal subpaths

Compression criterion:
the fewer subpaths are needed, the better α matches the routing preference
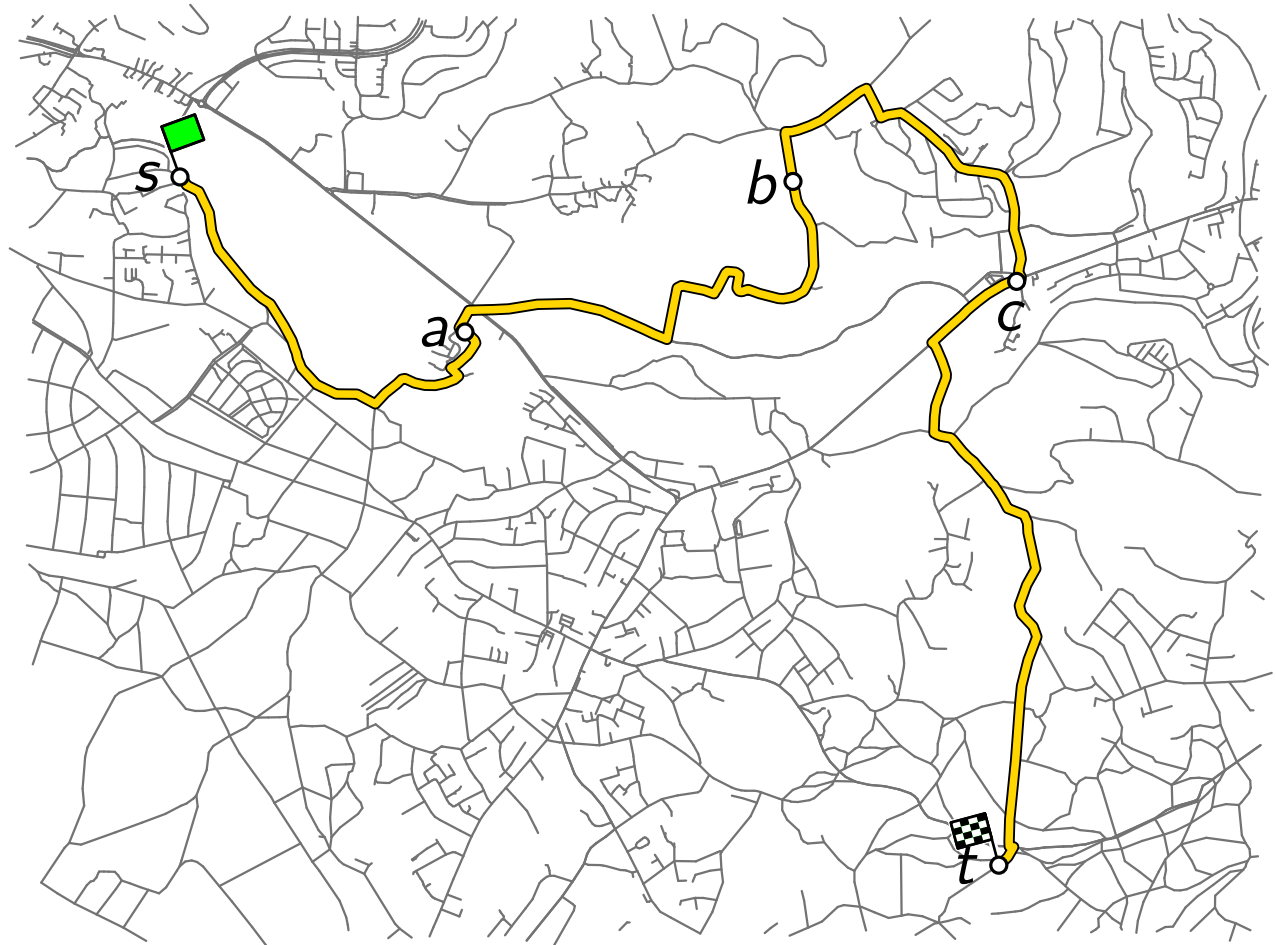
Milestone Segmentation

segment the trajectory into α-optimal subpaths

Compression criterion:
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$\alpha = 0.56$
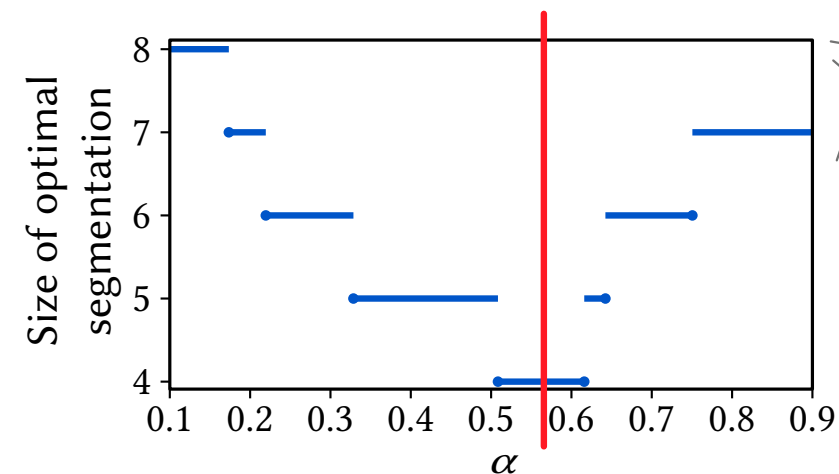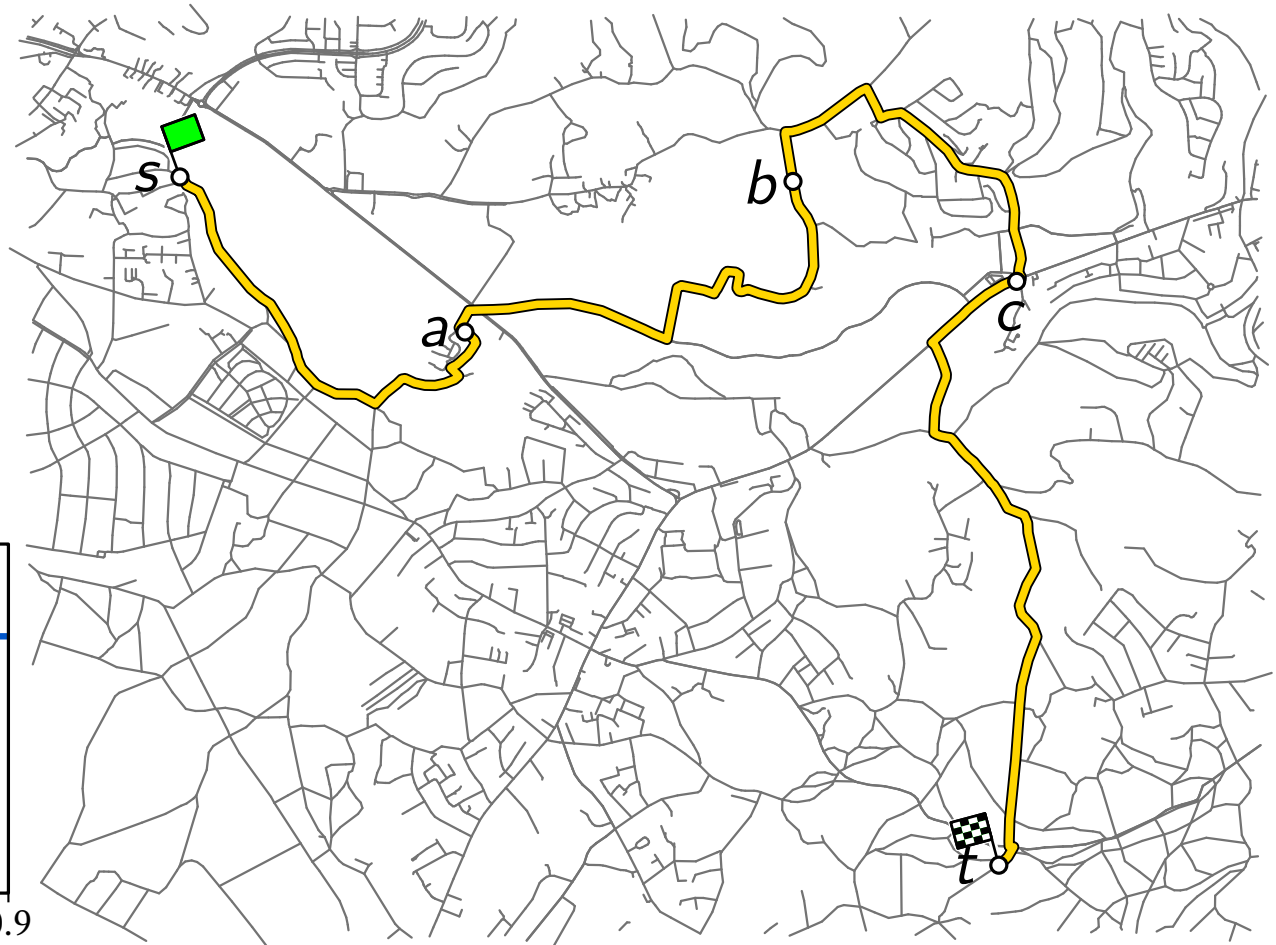
Milestone Segmentation

segment the trajectory into α-optimal subpaths

Compression criterion:
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$\alpha = 0.80$
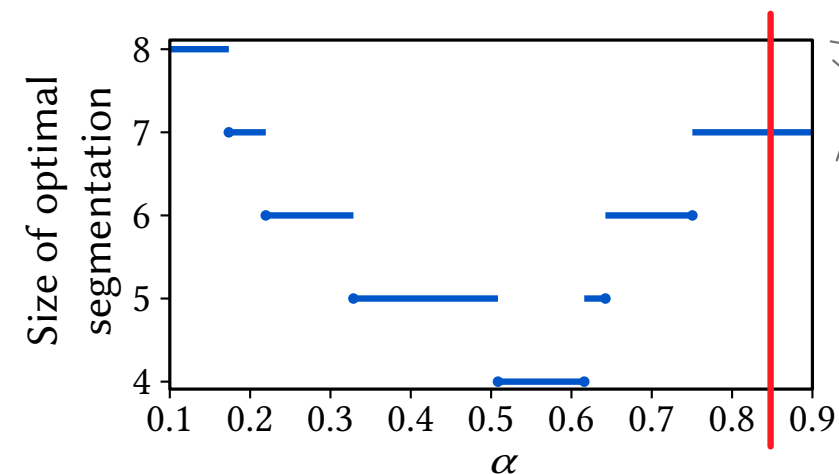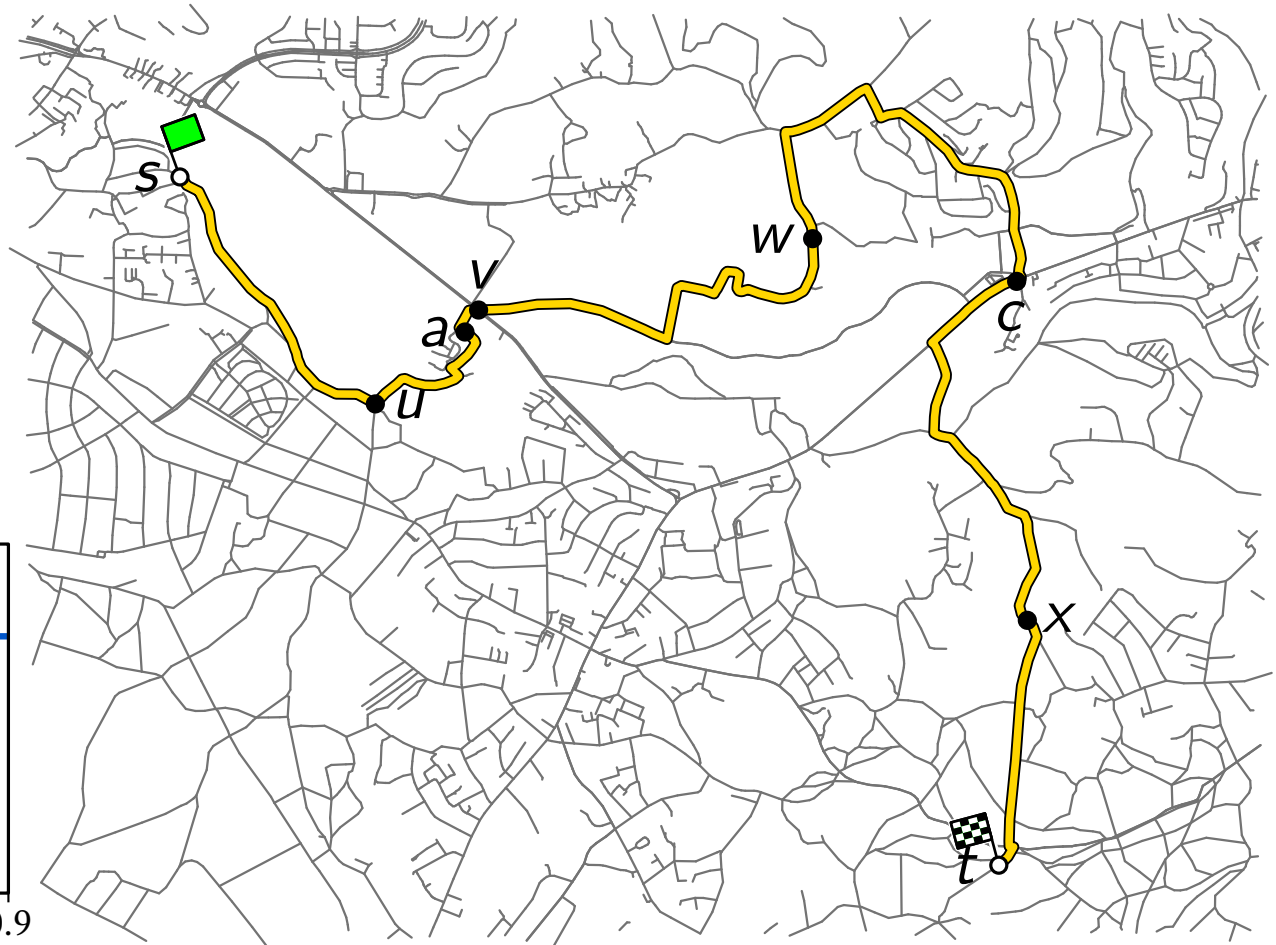
Signposted Cycling Routes
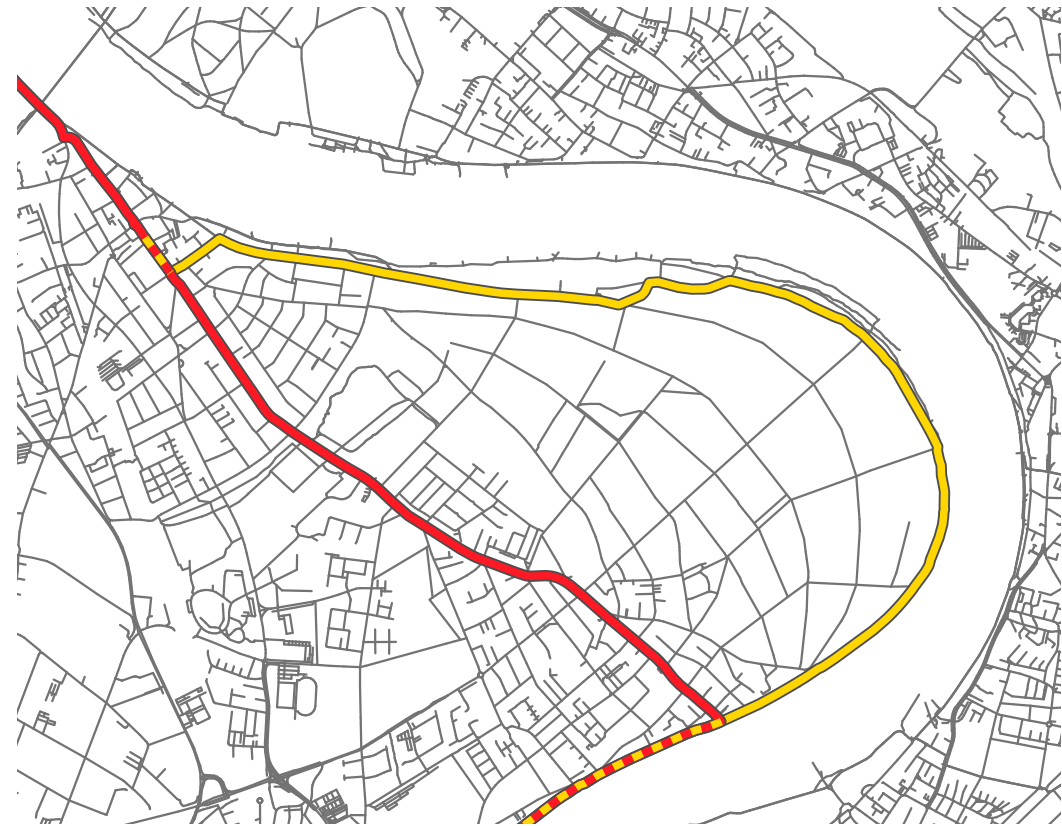
road/path

cyclist 1

cyclist 2

Signposted Cycling Routes
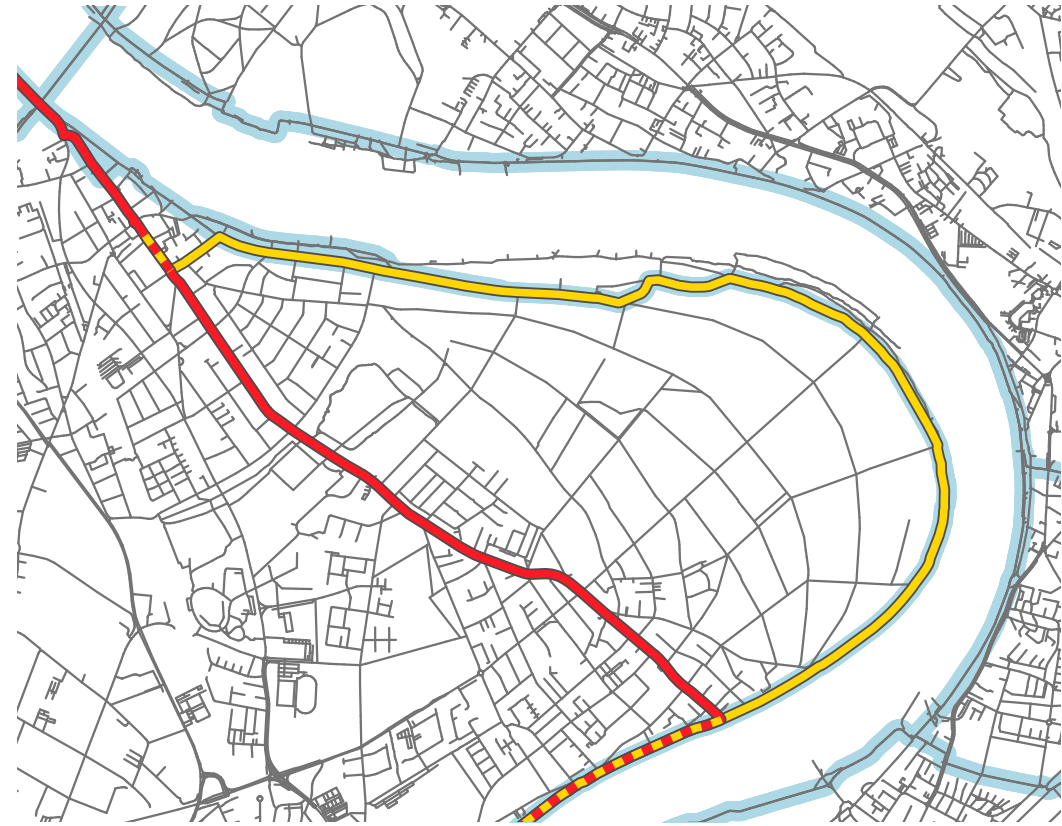
road/path

cyclist 1

cyclist 2

signposted
cycleway

Signposted Cycling Routes

$$w_\alpha(P) = (1 - \alpha) \cdot w_r(P) + \alpha \cdot w_c(P)$$

$w_r(P) =$ length of all signposted
sections of path P

$w_c(P) =$ length of all non-signposted
sections of path P
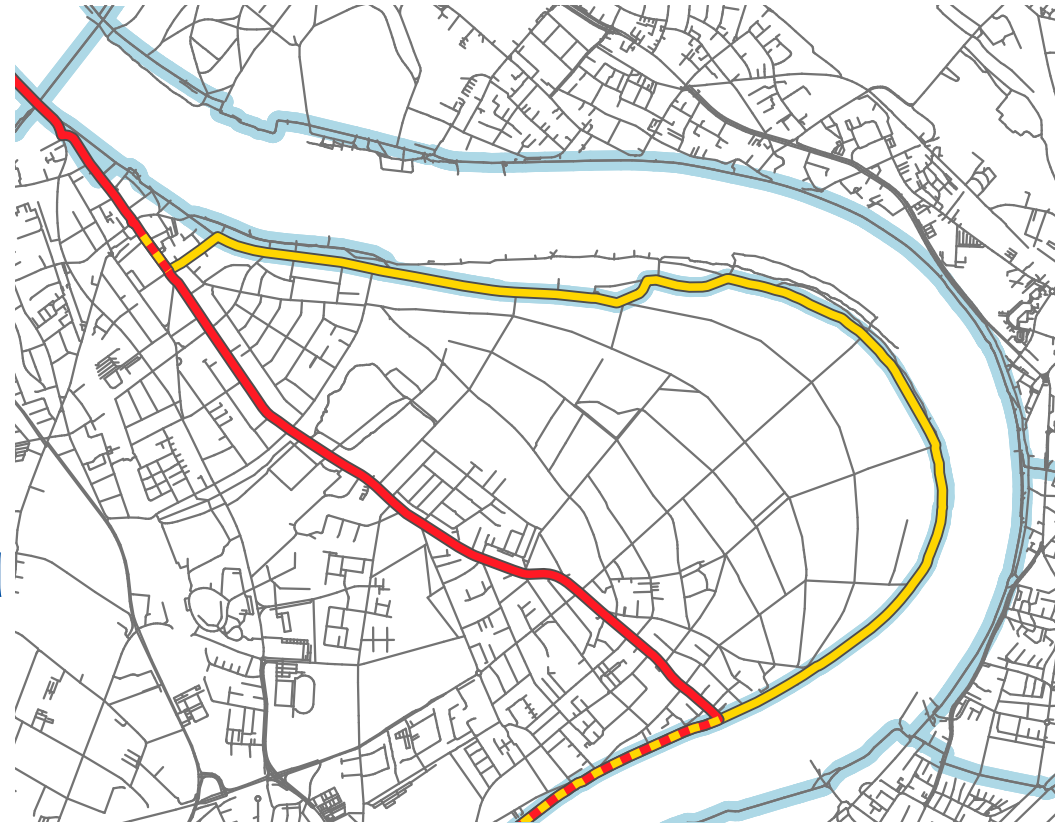
— road/path

— cyclist 1

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signposted
cycleway

Signposted Cycling Routes

$$w_\alpha(P) = (1 - \alpha) \cdot w_r(P) + \alpha \cdot w_c(P)$$

$w_r(P)$ = length of all signposted sections of path P

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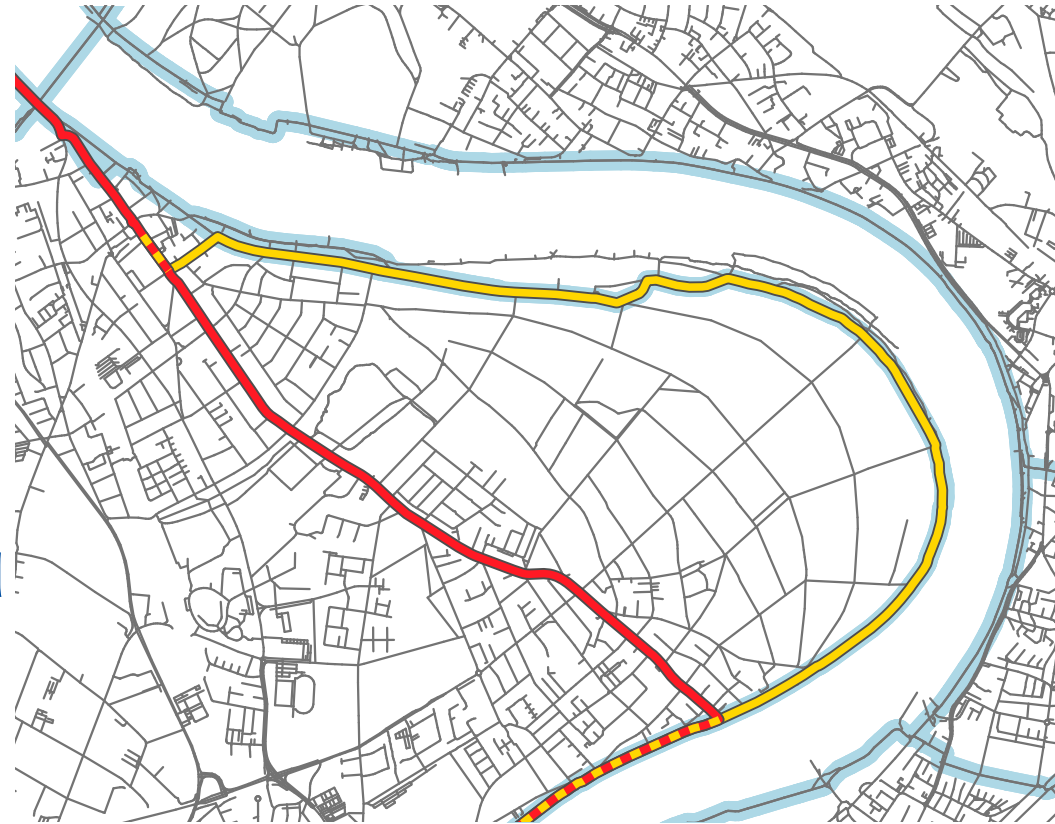
using this definition makes α interpretable:

$\alpha = 0.5 \qquad \Rightarrow$ geometric shortest path

$\alpha = 0.6 \qquad \Rightarrow$ detour of 50% to stick to signposted ways

— road/path

— cyclist 1

— cyclist 2

■ signposted cycleway

Experiments

set of 1 758 trajectories recorded by cyclists in Cologne
grouped according to their preference on signposted paths

CON $\quad \alpha < \frac{1}{2}$

INDIFF $\quad$ else

PRO $\quad \alpha > \frac{1}{2}$

share of all trajectories
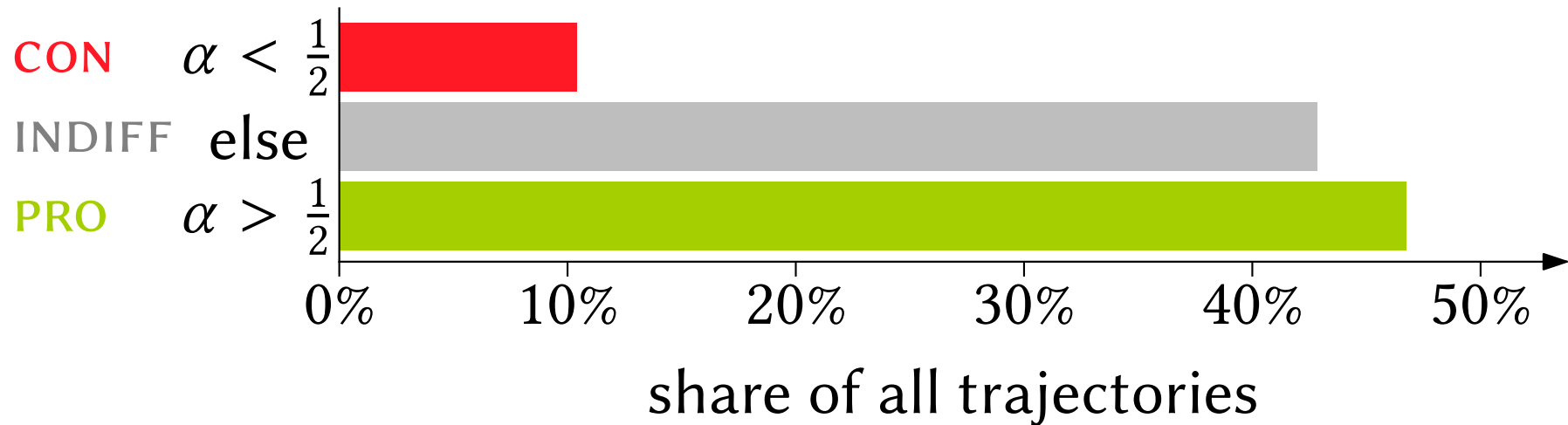
cyclists in the group PRO are willing to cover more than 40%
extra distance in order to stick to signposted paths

Trajectory Processing Toolchain
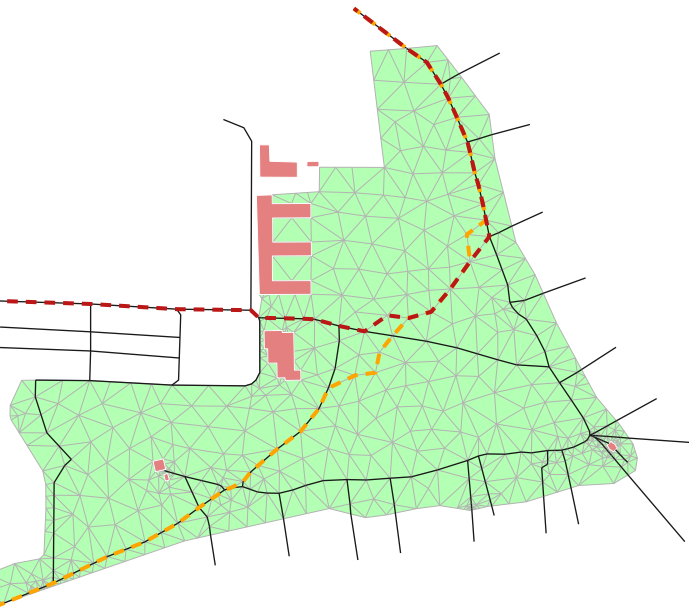
Map Matching

Trajectory Processing Toolchain
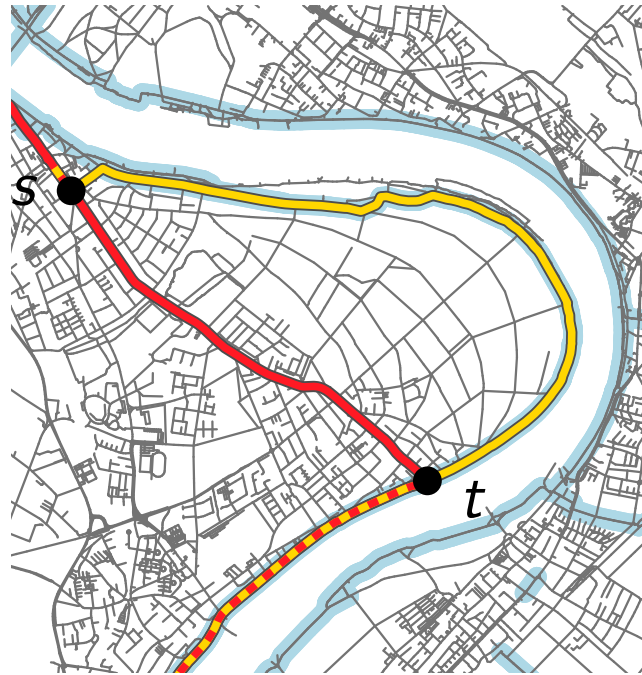
Map Matching

Learning Routing
Preferences

Trajectory Processing Toolchain

Map Matching
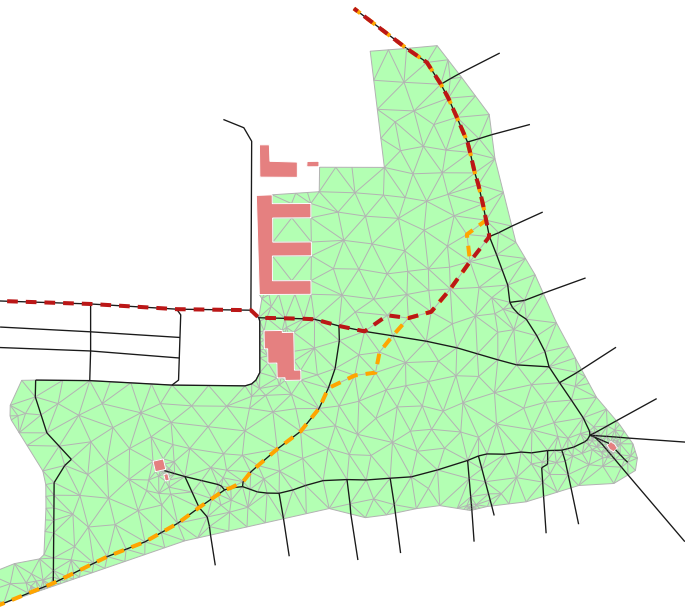
Learning Routing
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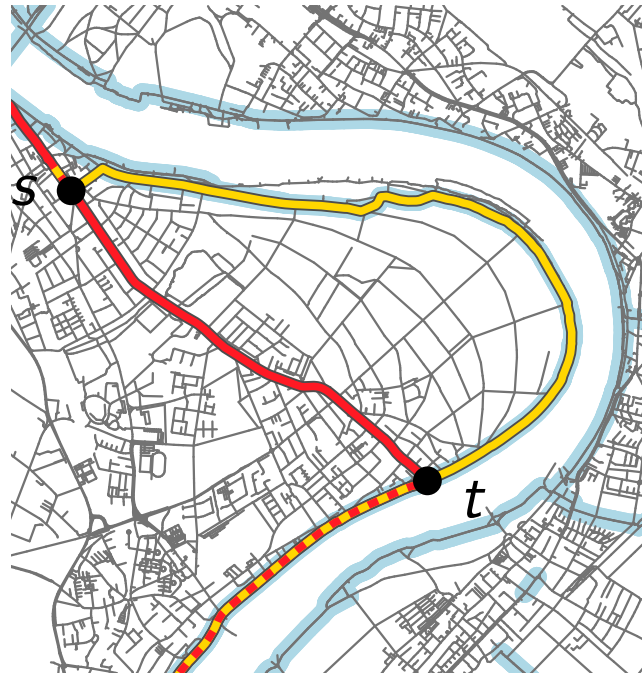
Visualization
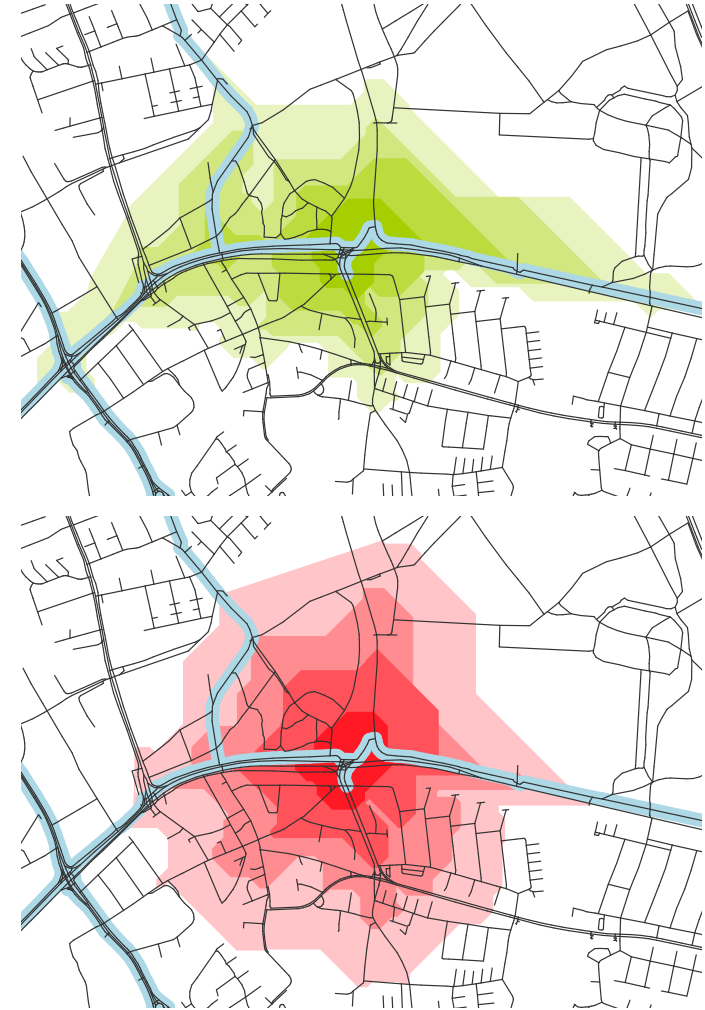
Main Contribution
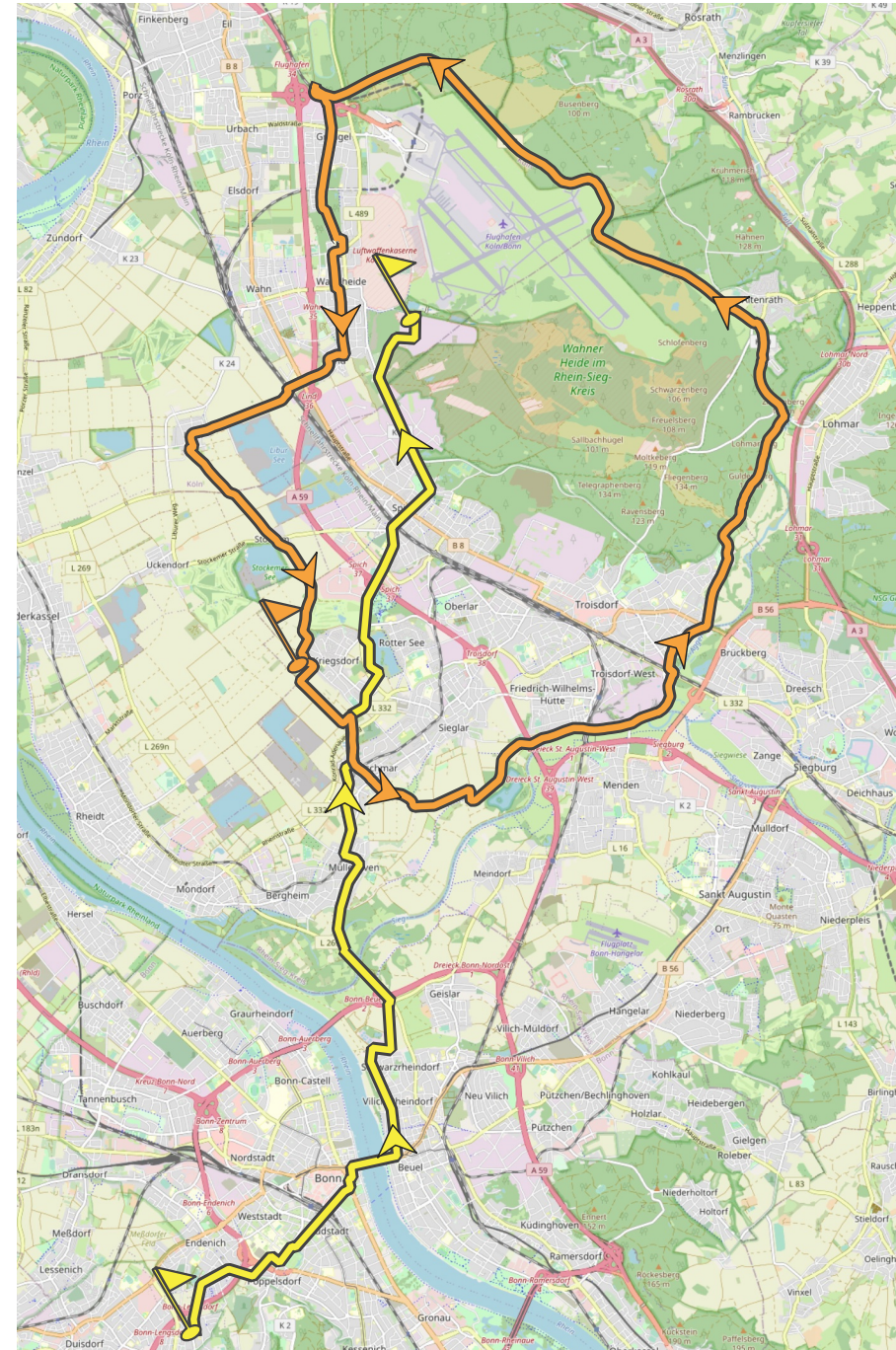
Tool to infer routing preferences from trajectories

Main Contribution

Tool to infer routing preferences from trajectories

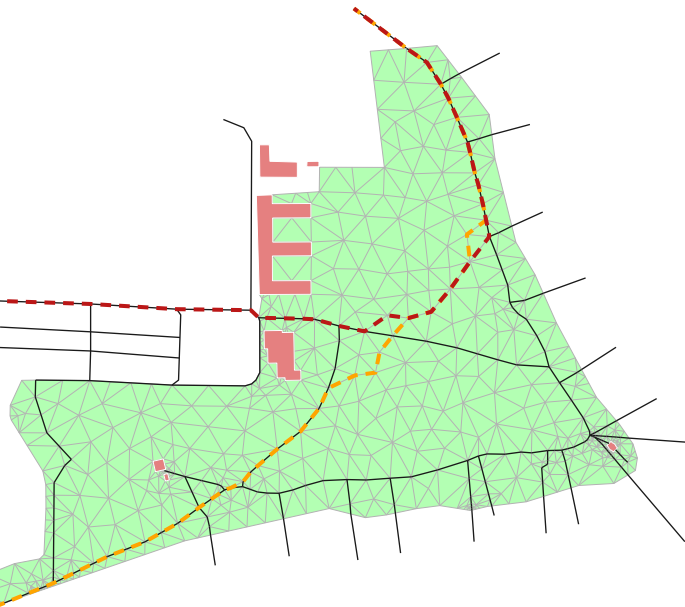- applicable for all trajectories
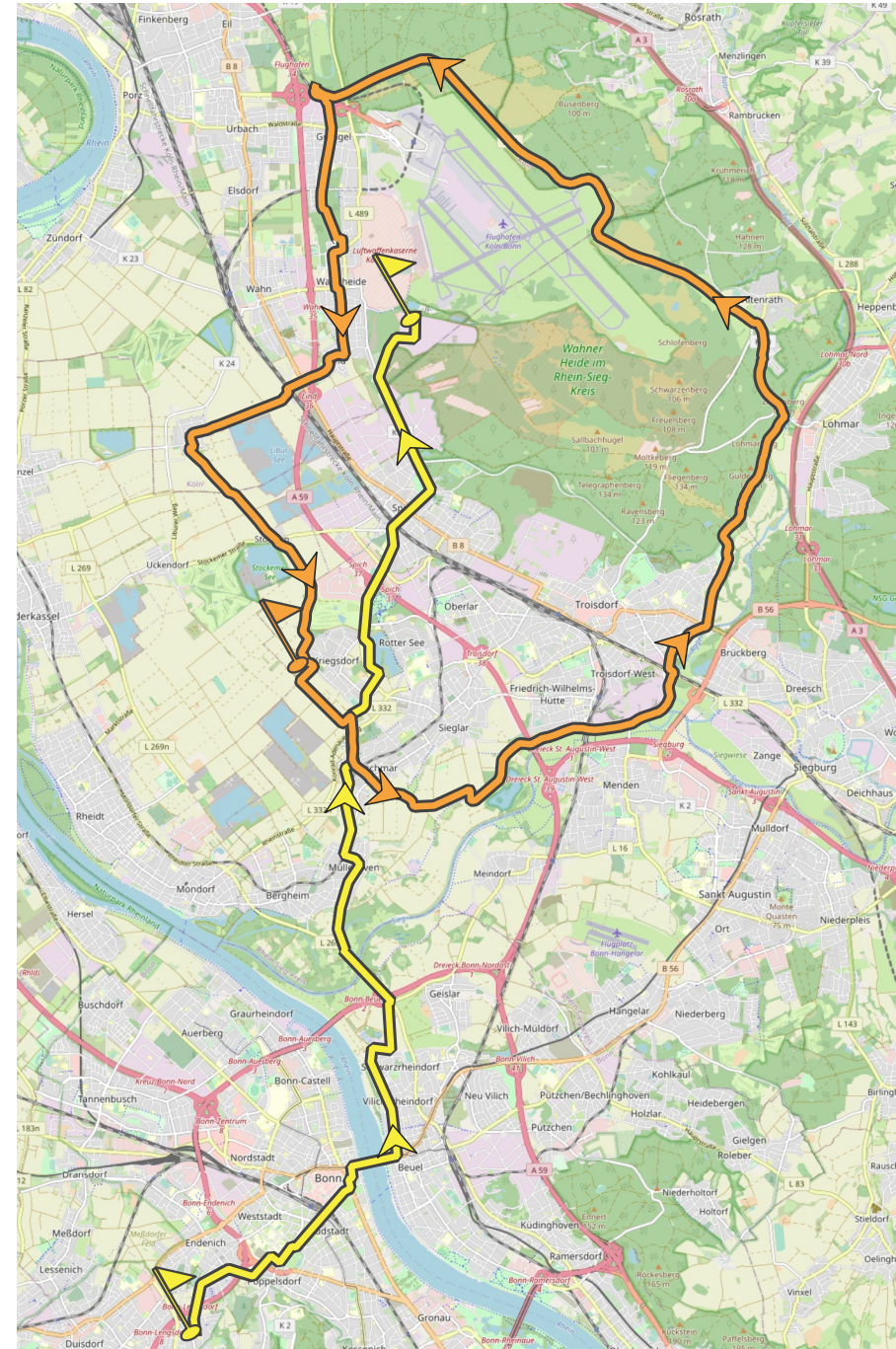
Main Contribution

Tool to infer routing preferences from trajectories

- applicable for all trajectories

- applicable for single trajectories
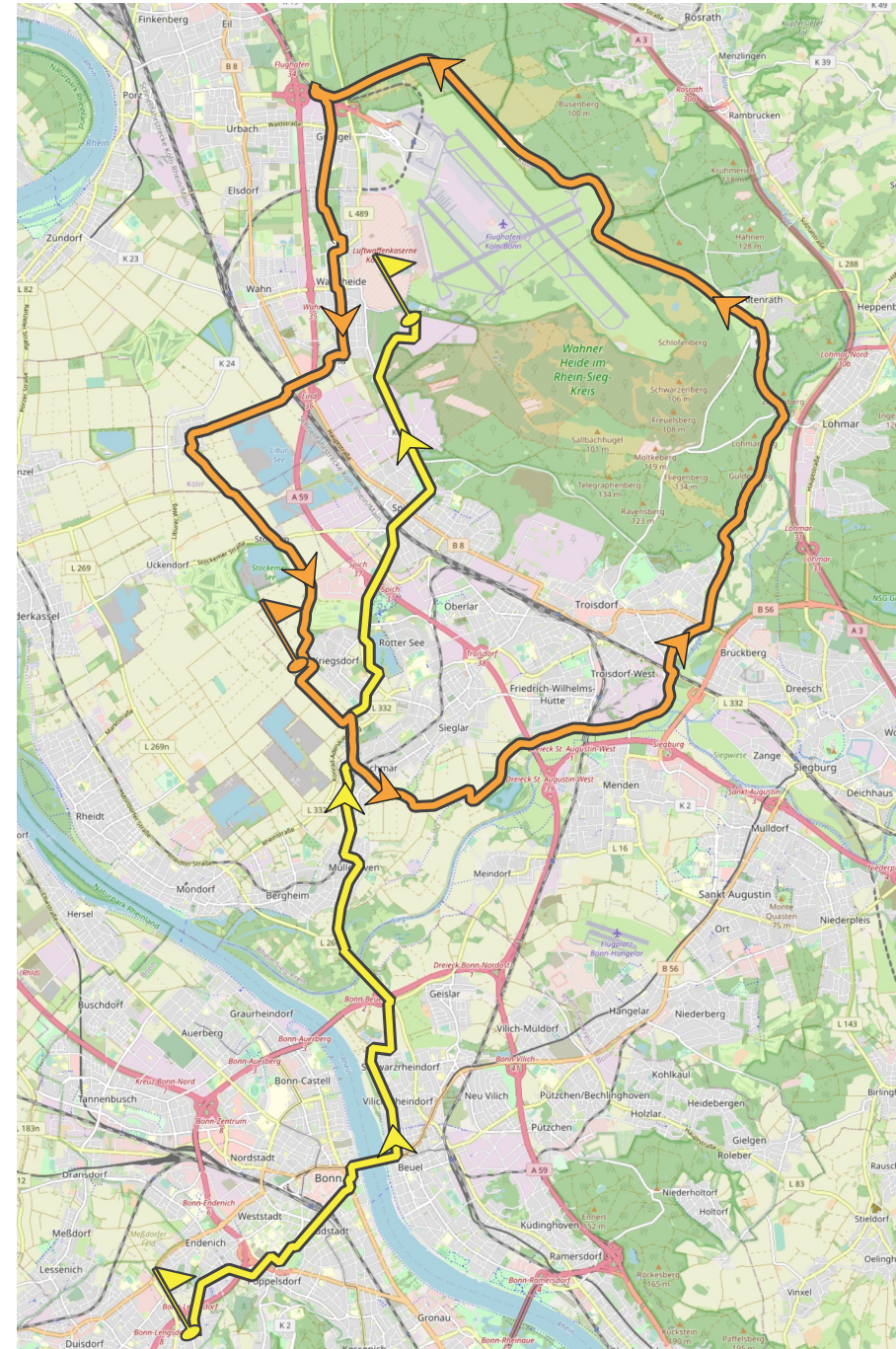
Main Contribution

Tool to infer routing preferences from trajectories

- applicable for all trajectories

- applicable for single trajectories

- detected significant influence of:

    - signposted cycleways

    - route ascent
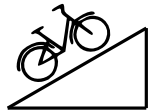
    - route complexity

on routing behavior

Future Work

- extend approach for multiple criteria

distance   traffic   signposts

surface   complexity   scenery   •••
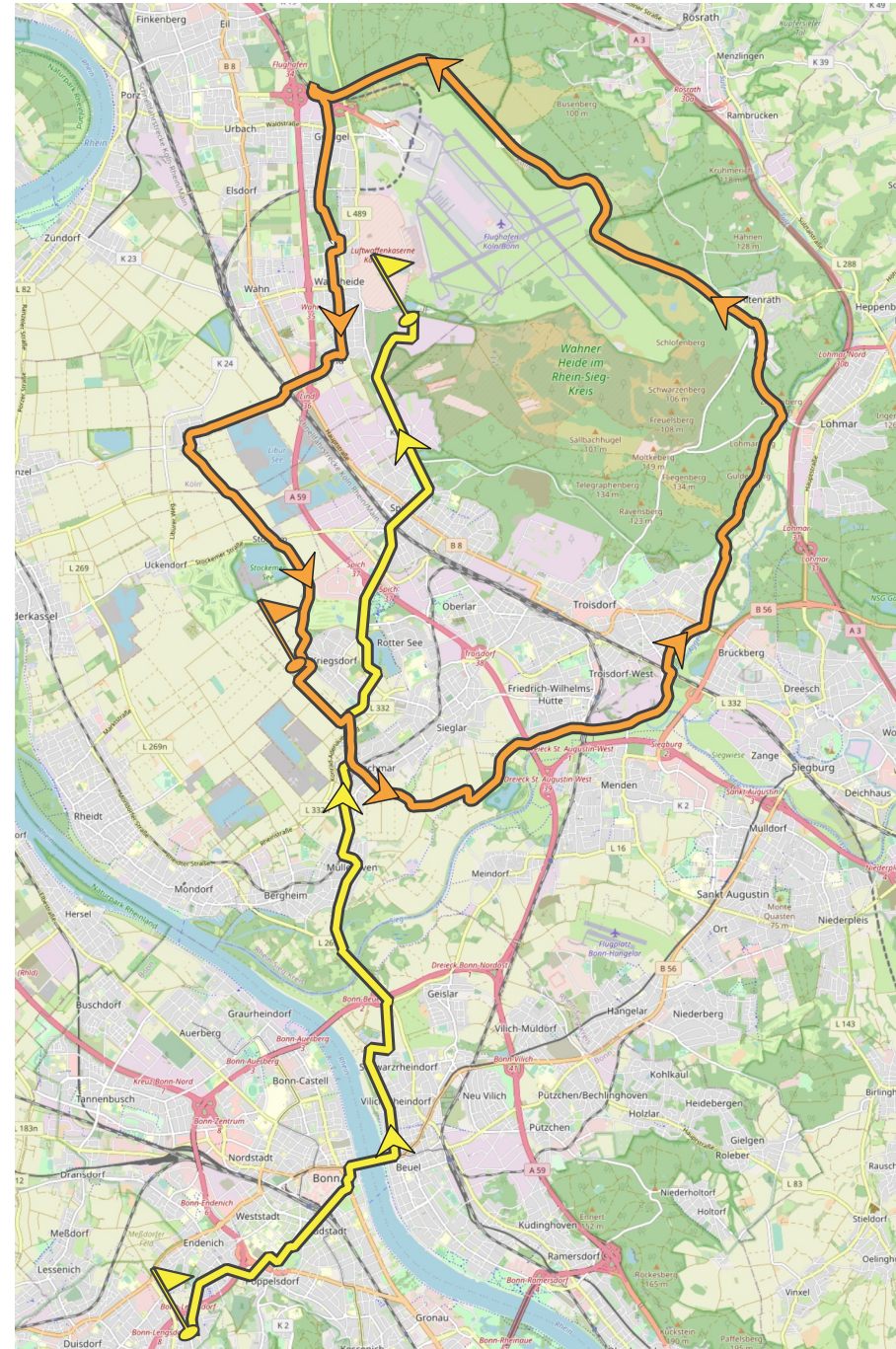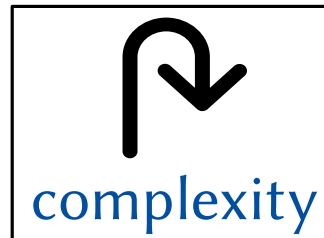
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- extend approach for multiple criteria

Future Work
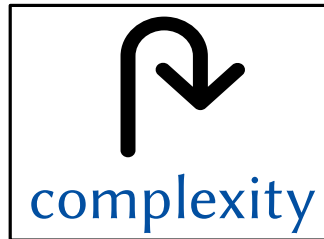
- extend approach for multiple criteria

- validate results based on explicit preferences

    - explicit → as stated by user

    - implicit → as shown by behavior

Thank you for your attention!

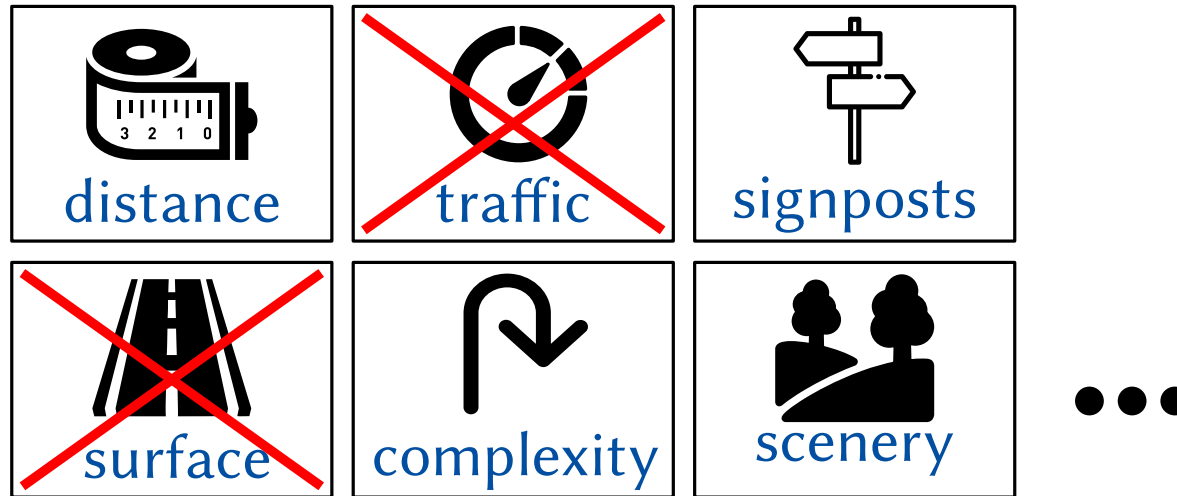**Forsch, A.**, Dehbi, Y., Niedermann, B., Oehrlein, J., Rottmann, P., & Haunert, J. H. (2021). Multimodal travel-time maps with formally correct and schematic isochrones. *Transactions in GIS*, 25, 3233–3256.

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