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A novel Machine-Learning, Multi-Criteria, Centralized, Bicycle Routing Algorithm

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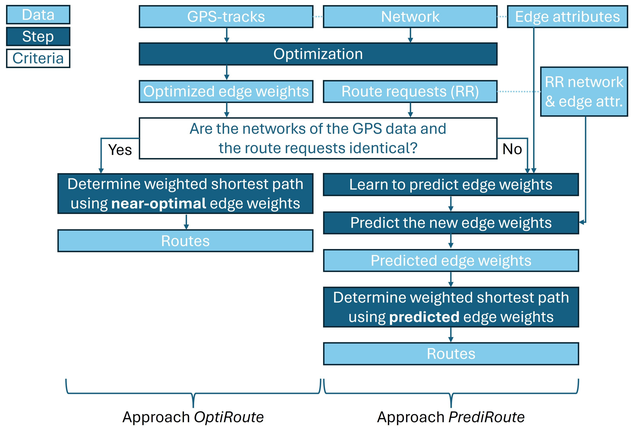
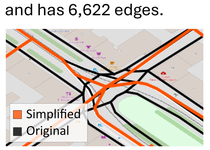
Motivation & Approach

We here present a two-fold approach for generating bicycle route predictions in an **efficient** and **multicriterial** manner, given that dense **GPS-data** is available of the region of interest or another region. First, we optimize the link weights using the GPS-data. Then, we make the approach **transferable** to other networks/regions by learning to estimate the link weights.

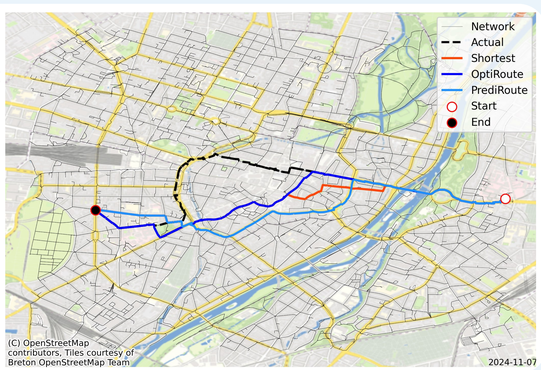


Case Study

Network: The OSM network of central Munich is simplified while preserving & adding data [1]. The network is directed, 4x4km², and has 6,622 edges.



GPS-data: 5,908 tracks from *Mobilität.Leben* [2].



OptiRoute: Optimized Link Weights

In *OptiRoute* we leverage the **GPS-data**

- An **Evolutionary Algorithm** is used to define the optimization problem

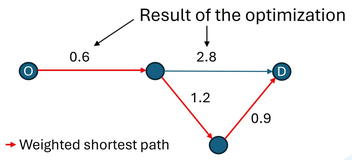
  $Minimize\ \left(1 - \overline{APC(a,p)}\right)$ for actual route A and predicted route P

  where Actual Path Coverage $= APC = \frac{\sum_{e \in A \cap P} length(e)}{\sum_{e \in A} length(e)}$

- Predicted routes are generated using the weighted shortest path with the optimized weights

This approach is inherently bound to the network for which the link weights are optimized:

- It cannot account for changes in the network, unless new GPS-data is available



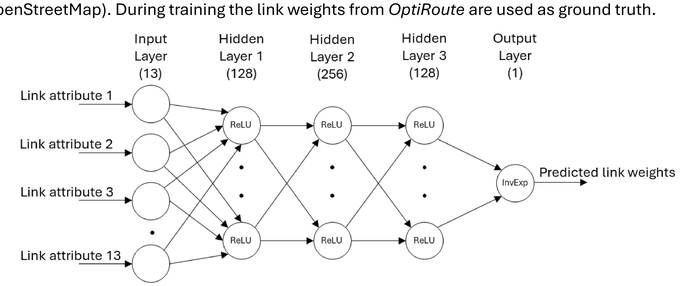
PrediRoute: Estimated Link Weights

With *PrediRoute* we aim to make the model regionally transferable and to allow for changes in the road network, while also facilitating real-time or large-scale applications.

Link attributes

- Cycle path width
  Segregated bicycle infrastructure
  Type of bicycle infrastructure
  Cycling surface quality
- Gradient
  Pedestrian crossing
  Road hierarchy
  Intersection importance
- Speed limit
  Number of car lanes
  Accessible by car
- Share of green areas
  Share of retail areas

A **neural network** learns to estimate the link weights **based on link attributes** (derived from OpenStreetMap). During training the link weights from *OptiRoute* are used as ground truth.

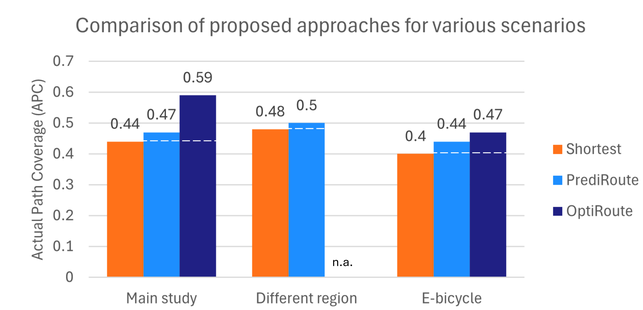


Results

The three sets of **link weights** are generated:

- For *OptiRoute*: by running the evolutionary algorithm (39hr)
- For *PrediRoute*: the model is trained (26s), and the weights of all links are estimated (0.04s)
- The shortest distance-based path is used as benchmark

To obtain the predicted routes, the **weighted shortest path** must be generated using the Dijkstra algorithm and the respective set of link weights. The runtime is 2.1 ms per predicted route.



We also test the model **transferability** to e-bicycle data and on a regionally different network (without retraining the models), and observe similar results.

Conclusions

Overall, we observe that the proposed models outperform the distance-based shortest path: *OptiRoute* by 15 percentage points and *PrediRoute* by 3 percentage points for APC. This also holds true for regionally different data and for e-bicycle data. Future works includes improving *PrediRoute* by considering more edge attributes or potentially incorporating graph-based models.

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References:

[1] OSMNetFusion on Github

[2] Loder, A., F. Cantner, V. Dahmen, K. Bogenberger, The Mobilität.Leben Study: a Year Long Mobility-Tracking Panel, 2023

OSMNetFusion LinkedIn ResearchGate