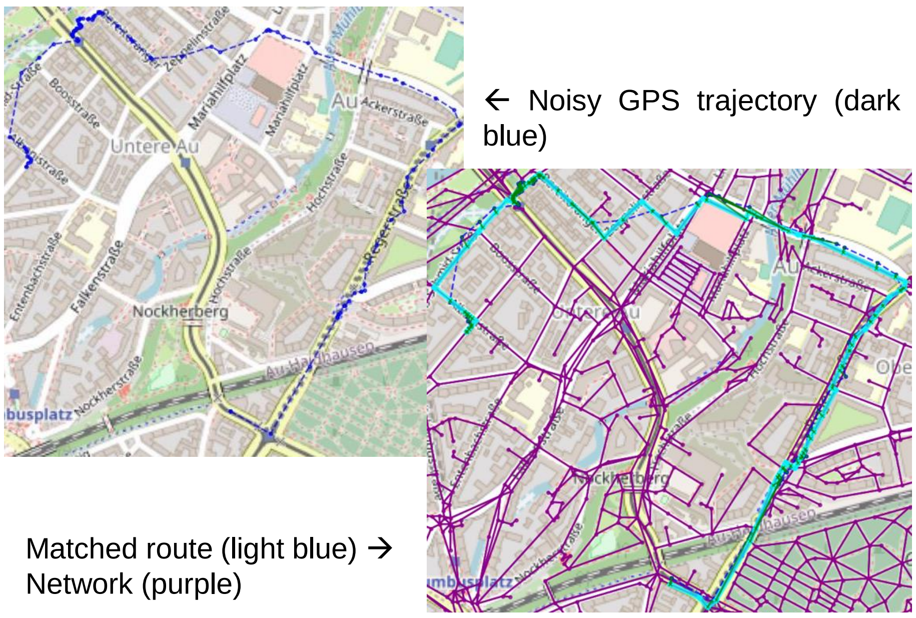
Development of a map matching algorithm for bicycle trajectories

Master‘s Thesis of Felix Thun

Mentors:
Victoria Dahmen, M.Sc.
Dr. sc. ETH Allister Loder
Dr.-Ing. Simone Weikl



← Noisy GPS trajectory (dark blue)

Matched route (light blue) →
Network (purple)

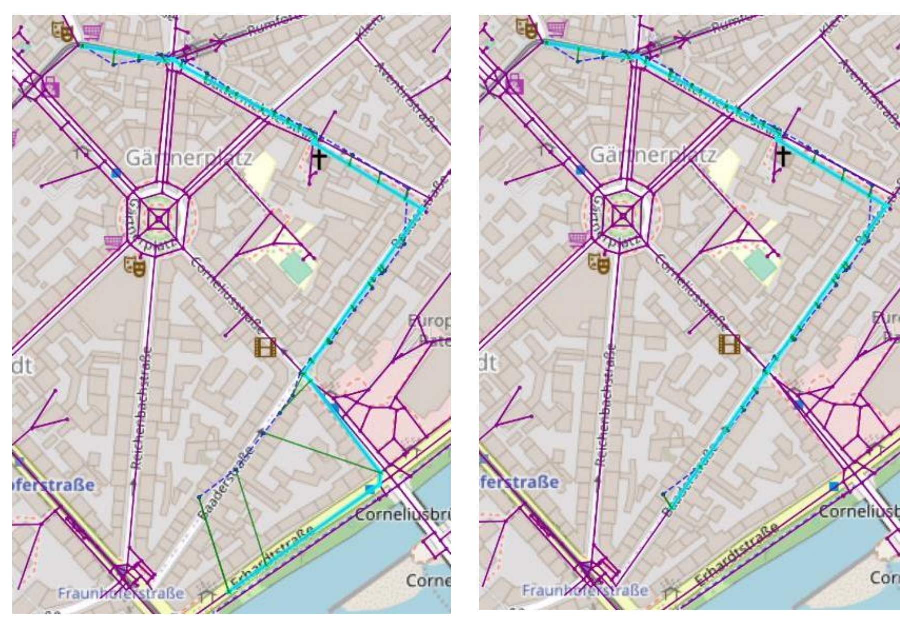
- Input: Noisy GPS trajectories of cyclists in Munich
- Aim: Identification of the originally driven route
- Tools: Cycling Network, Map matching algorithm

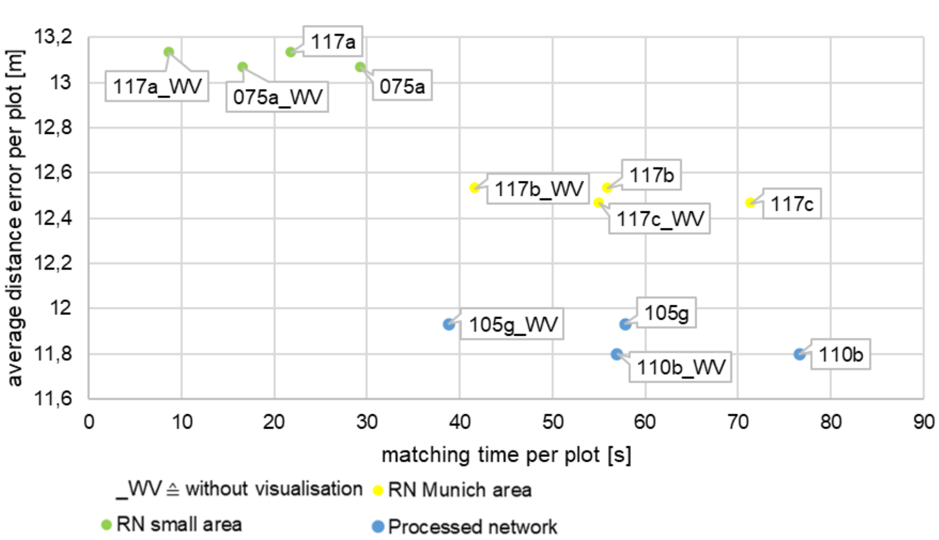
A map matching algorithm tries to identify the original route by analysing the noisy GPS data and comparing it to a network. The trajectories are noisy due to inaccuracies in the GPS detector like clock errors and atmospheric effects that disturb the signal on the way from the satellites to the GPS detector [1]. The algorithms use geometric and topological information to identify the correct position of every GPS measurement [2]. More advanced algorithms use further mathematical models to improve the matching result [2]. The Leuven.Mapmatching algorithm is used for this thesis as it is an open-source algorithm and can be adapted using Python.

In the plots, purple lines present the network, dark blue lines the GPS trajectory, light blue lines the matched route, and green lines the distance between the two blue lines.

The algorithm needs a network of edges and nodes to match the GPS measurement on them. Therefore, a raw network (RN) is used including different types of layers for different modes based on OSM data. Secondly, a processed network (PN) is used where the basis of OSM data from whole Munich is simplified to reduce the number of edges in the network and to save computational time.

First tests were executed to analyse the different adaptable parameters of Leuven.Mapmatching. Additionally, an extension of the algorithm is applied to handle one-way streets that a directed in the original network, but cyclists might also use the opposite direction (see the difference in figures on the right). As a result of the raw network, a combination of two parameter sets leads to a usable result. The evaluation of the different variants is done by comparing the computational time, the average distance error (the average distance between the GPS trajectory and the matched route), and the presence of errors like detours.





The processed network shows advantages in computational time as parts of the network are simplified. However, the accuracy was in the same range as the raw network, so the processed network is a good variant for this size of project area (see blue dots in figure on the left). For smaller areas, the raw network can be a good alternative as the computation time is less and the average distance error comparable (green dots in the figure on the left).

Further improvement of the network and the use of additional input parameters like GPS time stamps or acceleration measurements might improve the result as far as a distinction between different lanes on the same street is possible.

Sources: background of plots: OpenStreetMap. © OpenStreetMap contributors. Available: https://openstreetmap.org
[1] G. Xu and Y. Xu, GPS: Theory, algorithms and applications (Earth sciences). Berlin, Heidelberg: Springer, 2016, doi: 10.1007/978-3-662-50367-6.
[2] M. A. Quddus, W. Y. Ochieng, and R. B. Noland, “Current map-matching algorithms for transport applications: State-of-the art and future research directions,” Transportation Research Part C: Emerging Technologies, vol. 15, no. 5, pp. 312–328, 2007, doi: 10.1016/j.trc.2007.05.002.