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Optimizing the Operation Range of E-Bikes in Routing Systems

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1 Introduction and Method Overview

The thesis presents a routing system capable of computing the ideal route in terms of energy consumption for electric bicycles. It proposes a static energy model for electric bicycles based on related work [1, 2], which allows to compute energy requirements for arbitrary street segments in an automated processing pipeline (ArcGIS Model Builder), given contextual information such as an Open Street Map (OSM) road network, a digital elevation model (DEM), and parameters like weight, desired speed, or the presence of a recuperation mechanism. The hereby built route graph is embedded within a stand-alone routing application employing the Bellman-Ford algorithm [3] accessing the generated data from a relational database management system (RDBMS) PostgreSQL (extended by PostGIS and ArcSDE). It can be used to compute the route with the lowest energy demand (Fig. 4) or farthest cruising range estimations (Fig. 3). Together with data collected from several test rides, the application was used to estimate and validate the model parameters.

2 Evaluation

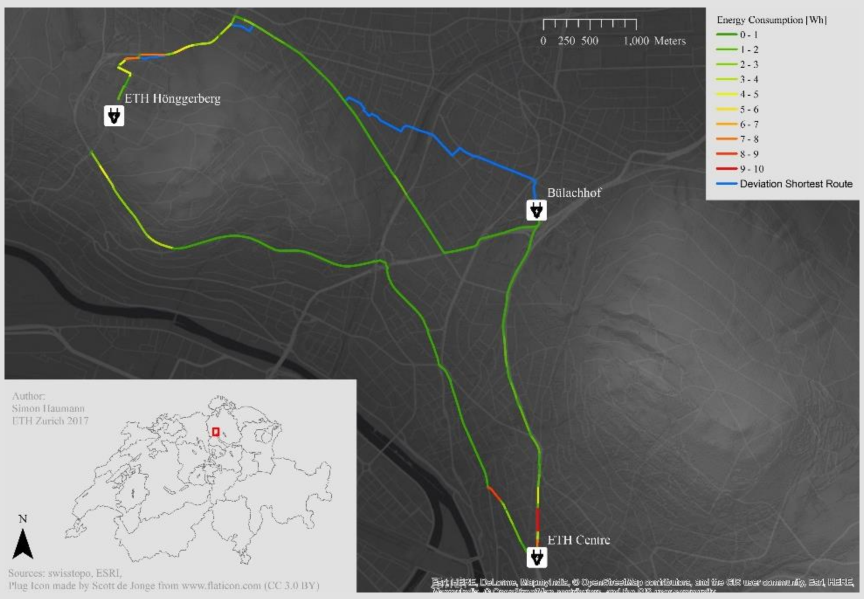

Fig. 1. The Map shows the test tracks with the modelled energy consumption per street segment from the test without recuperation. It also compares the calculated energy-based routes with the shortest routes in terms of distance.

To tune the model, five repetitive test drives on three routes were performed (Fig. 1). The tests were carried out with adapted input parameters, i.a. considering the specific temperature on that day and the weight of the subject. The average deviation between measured and modelled values was around 16 % (Fig. 2).

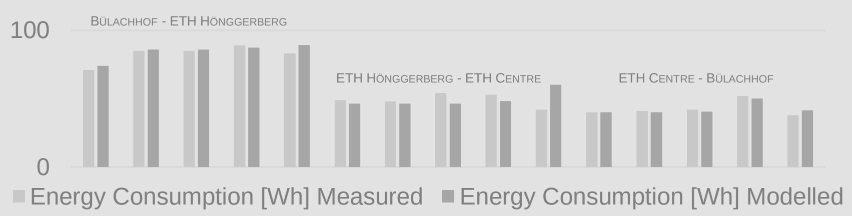

Fig. 2. The Diagram shows an example for the gathered data for the first test session with a bike without recuperation mechanism. Measured and modelled values are compared. Additional test drives with a bike with recuperation were performed.

3 Results

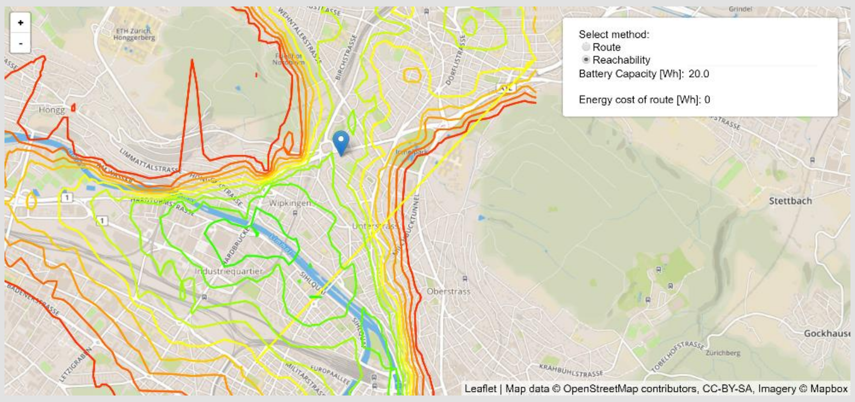

Fig. 3. Prototypical routing application with a reachability request. The example shows the maximum remaining cruising range with a SOC of 20 Wh from an arbitrary location in Zurich.

Using data recorded during the test drives, the model's fit could be increased and initial evidence for the feasibility of the approach could be provided.

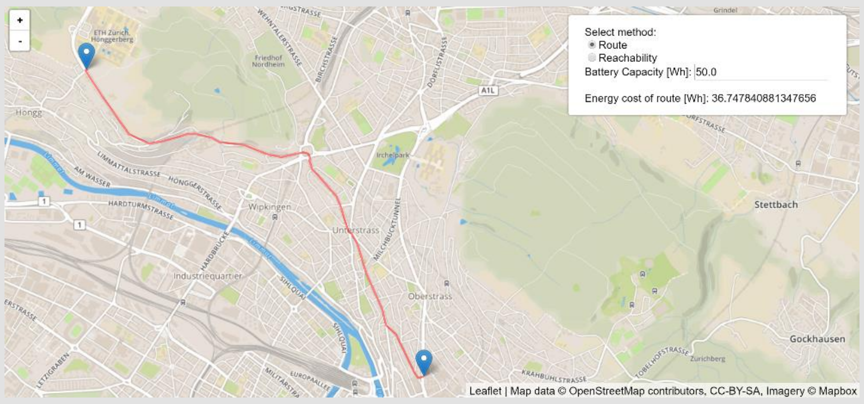

Fig. 4. Prototypical routing application with a routing request from ETH Hönggerberg to ETH Centre. This application takes into account recovered energy caused by recuperation in downhill segments.

4 Conclusion and Outlook

Although preliminary field tests could prove accuracy and precision of the model, several parameters such as the influence of the temperature need further empirical validation. One use-case of this technology is within a navigation system, where it can enable automatic switching from a shortest-path route in progress into energy-saving mode when a target destination becomes unreachable due to insufficient charge.

5 References

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