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Modelling road infrastructure potential for the appraisal of sustainable bicycling networks

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This work addresses the following topic(s) from the Call for Contributions:
(Please check at least one box)

☐ Placemaking to integrate urban spaces and mobility
☐ Promoting sustainable mobility choices in metropolitan regions
☐ Governing responsible mobility innovations
☐ Shaping the transition towards mobility justice
☒ System analysis, design, and evaluation
☐ other: _____

Extended Abstract

Problem statement

Movements for the expansions of urban cycling infrastructure have gained widespread support as a possible solution for sustainable transportation. Yet the evaluation of cycling network expansion strategies remains a challenge. Few studies conduct cycling investment appraisals during early strategic planning stages, which would be useful for prioritizing, selecting, and economically justifying the costs and benefits of cycling infrastructure investment (Liu et al., 2021).

One factor complicating investment appraisals for cycling networks in early project phases is the absence of a network-level overview of infrastructure extent – specifically, the road dimensions. Such an overview cannot be easily produced since the current road infrastructure is heterogeneous and largely dependent on the local context of the urban road space (Reggiani et al., 2022; Wysling & Purves, 2022). For example, the city of Zurich has no spatially explicit overview of the distribution of its road widths. The current best approximation is based on typical widths of the different road hierarchy types and their approximate distribution in the city. Since urban cycling infrastructure expansion is usually limited to transformations within the existing road space, road dimensions are important information for cycling investment decision-making. Without accurate information of road dimensions in early project phases, additional surveying is required in later project stages for planning individual interventions. This means that attempted appraisal of cycling investment decisions in the planning phase are likely to lead to unacceptable deviations of the estimated costs and benefits, simply because planners do not have data of the actual situation at hand.

Research objectives

This research aims to improve the appraisal of cycling network investment decisions in early planning stages by providing a method for automated road dimension identification. This method will produce a spatially explicit model of road dimensions, providing an overview of the potential transformable space that is available for

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interventions. Such an overview provides the basis for appraisals of possible network expansions, including their possible costs and benefits, supporting planners in early planning stages when analysing alternatives for changing urban infrastructure networks. This will improve the investment decision-making process and better support decision-making for the transformation of urban road networks into ones that support sustainable transportation through prioritizing cycling. The method shall rely on widely available, open-source data, so that it may be applied in other contexts (i.e., cities outside of Switzerland).

Methodological approach

A supervised machine learning algorithm to segment rasterized aerial image data will be developed to determine road geometries. This approach builds on previous research (e.g., Ruiz et al. (2011)). Open-source data, including OpenStreetMap and satellite imagery, will serve as the input data.

More specifically, the inputs to the model will be 1) a pre-processed, simplified edge-node road network representation based on OpenStreetMap data (Ballo & Axhausen, 2024), and 2) aerial imagery of the roads. A labelled dataset of road geometries is created using the vectorized transport land cover database from the Canton of Zurich. The model will be trained on this test set to predict the road geometries of any road from its aerial imagery.

Having trained the model and created the geometric overview of Zurich's road network, different transformation alternatives will be examined. For example, roads of different widths will be transformed in different ways, incurred costs and benefits will be computed, and the aggregated impacts on the entire network will be appraised. Insights into the impact of potential changes on the urban cycling network will thus be quantified, demonstrating the usefulness of the proposed model.

Expected results

Work has been completed on the appraisal of network-wide cycling infrastructure transformations in Zurich. The results include cost-benefit analyses of such transformations. However, these results are based on approximations of Zurich's road space that do not allow interventions to be considered spatially explicitly. Therefore, to further improve these results, this research expects to achieve the following outcomes:

- Creation of a machine learning-based process for identifying road geometries. The model will quantify the network potential for cycling infrastructure based on existing road space. It will rely on open-source data so that it can be used in other regions without strict data requirements.
- Demonstration of the model's contribution to efficient network transformation appraisals. The Zurich case study will show how the model can be employed in urban infrastructure planning, specifically for network-level expansion planning of cycling infrastructure. Differences using this model versus the currently available road dimension data in Zurich will be shown.

This research proposes a method for more efficient and data-driven decision-making in urban cycling infrastructure planning. By developing a model that supports consideration of cycling benefits, infrastructure construction costs, and existing infrastructure potential, this research paves the way for a more sustainable and interconnected urban cycling network, ultimately promoting healthier, environmentally friendly transportation options in urban areas.

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