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Observing Cyclists' Mobility Patterns for better Decisions

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Abstract

Although the amount of data, generated in the mobility domain, has been increasing dramatically over the past years, specific cycling-related data are still hardly ever employed as the evidence base for cycling promotion. This is due to lacking data availability and accessibility on the one hand and to the absence of frameworks for integrating data from a different source on the other hand. We, therefore, propose a Bicycle Observatory, which facilitates a continuous observation of cycling mobility and serves as decision support in the broader context of cycling promotion. In this study, we investigate the contribution of a Bicycle Observatory achieving of strategic goals in cycling promotion and summarize major requirements and recommendations for establishing a Bicycle Observatory.

Keywords: cycling, bicycle observatory, evidence base, cycling promotion, monitoring

1 Introduction: cycling data

Cycling data are commonly regarded as essential for planning and decision-making processes. Due to the rise of cycling in many cities and regions, the demand for valid data as an evidence base has constantly been rising. In parallel to this development, advancements in the ICT and wearable sector have led to growing amounts of generated data. Over the past ten years, numerous studies contributed to an optimistic perspective on transport data availability in the broader context of "Smart Cities" and the "Internet of Things" (IoT). Miller and Shaw (2015) see huge potential in data from mobile sensors when it comes to the investigation of mobility patterns and behaviour. In the context of big data and smart urbanism, Kitchin (2014) appraises new opportunities for gaining insights into cities and their governance. Anda et al. (2017) regard big data, opportunistically collected by wearables, as game-changer in transport modelling.

In a recent review of available pedestrian and bicycle data, Lee and Sener (2020) distinguished between traditional data sources, such as counts and travel surveys, and emerging data. The latter are all generated by wearables with location sensors, ranging from GNSS to Wi-Fi and Bluetooth, and user-generated data, such as system data from bike-sharing systems or feedback in citizens' apps. The authors point to the fact that there are still a lot of open questions connected to emerging data sources. These range from mode detection, data validity, sampling bias, privacy, to a lack of contextual information and costs for obtaining and utilizing the data. Thus, it is not surprising that a substantial gap between theoretical opportunities and common daily practice becomes evident. Steenberghen et al. (2017) investigated the availability of mobility data from cyclists and pedestrians in the European Union, plus Norway and Switzerland. In interviews with national representatives, the authors found that only 40% were able to determine the average distance cycled per person at the national level. For cities and regions, where a sound evidence base for planning decisions and implementing measures is most needed, the situation is expected to be even worse.

Independent from data availability, different data sources need to be integrated for a holistic perspective (Romanillos et al., 2016, Conrow et al., 2018). However, a standardized framework for how to relate different data to a common picture of cycling mobility does not exist yet. Consequently, we are facing two interlinked issues: a lack of data availability and accessibility, especially at a local scale level, and the absence of concepts, frameworks or tools for data integration. Against this backdrop, we introduce a concept for a geospatial Bicycle Observatory (Loidl et al., 2020), which serves as an integrator of different data and allows for monitoring bicycle mobility in an integrated way. In this study, we are aiming for determining a Bicycle Observatory's contribution to achieving strategic goals with regard to cycling and identify the cornerstones of such a platform.

2 Bicycle Observatory

Instead of single measurements at specific locations and time periods, a Bicycle Observatory facilitates continuous and integrated measurements of cycling-related parameters. The concept is well established in different observational disciplines, such as astronomy, biology or economy. The application of an observatory for geographic information was proposed by Janowicz et al. (2014) and further elaborated by Miller (2017). Geographic Information Observatories (GIOs) facilitate holistic insights into geographic data and underlying phenomena. Since mobility is spatial and all data that are relevant for capturing aspects of cycling mobility, we applied the concept of a GIO and developed the concepts for a Bicycle Observatory (Loidl et al., 2020).

For this, the following data sources are tapped and technically integrated: spatial data (infrastructure, physical environment, and weather), movement data (trajectories from mobile applications), statistical data (census, crash reports), mobility surveys and qualitative data (surveys, data from feedback apps). These data have different temporal characteristics (sporadically or periodically updated, real-time) and spatial resolutions. However, the geographical reference facilitates the linking of these data sources. Decentral storage of the data ensures maximum efficiency in terms of data ownership and updating. In order to integrate data, spatial and temporal re-sampling methods need to be employed. Semantic interoperability is supported by Semantic Web technologies, such as ontologies (see Reda et al.2018) for an example in a related domain). We refer to existing approaches for dealing with heterogeneous and erroneous data (Loidl and Keller, 2015, Vaccari et al., 2009), which need to be user-tailored for the specific data set and purpose.

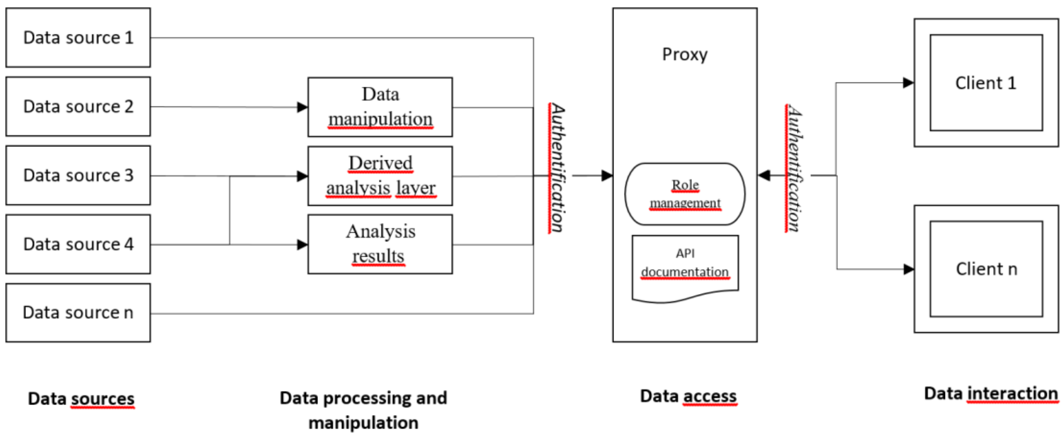

Figure 1: Concept of a Bicycle Observatory with decentral data storage (modified from (Loidl et al., 2020))

The Bicycle Observatory platform refers to the data sources and provides standardized interfaces for different clients (Figure 1). In a proof of concept (POC), we established a Bicycle Observatory for Salzburg and adjacent municipalities (Loidl et al., 2020, Leitinger et al., 2020, Heym et al., 2020, Brocza and Kollarits, 2020). The following investigations are based on this POC.

3 Supporting cycling promotion strategies

When it comes to supporting a modal shift towards cycling, cycling promotion strategies are fundamental for political decisions and implementation processes. In order to conduct an effective and credible cycling policy, sound data for status-quo analyses and monitoring are essential. We evaluated the contribution of a Bicycle Observatory to this demand. For this, we selected cycling promotion strategies at different administrative levels: the European Cycling Strategy by the European Cyclists' Federation (ECF)[1], the Masterplan for Cycling by the Austrian ministry for climate action (BMK)[2], the cycling strategy of the Austrian province of Vorarlberg[3] and the cycling strategy of the city of Salzburg[4].

We extracted all action fields and measures mentioned in the four strategies and evaluated how the integrated data provision in a Bicycle Observatory supports efficient implementation of the respective measure. The matching matrix revealed a strong relation, especially at a local level (Table 1).

[1]https://ecf.com/eu_cycling_strategy (last access: 2020-09-28)
[2]https://www.klimaaktiv.at/mobilitaet/radfahren/masterplan_RF_2025.html (last access: 2020-09-28)
[3]https://vorarlberg.at/documents/21336/80850/Kettenreaktion+Radverkehrsstrategie+Vorarlberg/ (last access: 2020-09-28)
[4]https://www.stadt-salzburg.at/smartcity/smarte-mobilitaet/radverkehrsstrategie-2025/ (last access: 2020-09-28)

Table 1: Matching of action fields and measures in cycling promotion strategies with a Bicycle Observatory.

Cycling promotion strategy	Number of action fields and measures	Number of matches
European Cycling Strategy	4	2
Austrian Masterplan for Cycling	25	7
"Kettenreaktion" – cycling strategy Vorarlberg	21	8
"Radverkehrsstrategie 2025+" – cycling strategy Salzburg	25	16

In a subsequent step, the most supported strategy by a Bicycle Observatory, namely the cycling strategy Salzburg, was investigated in-depth. For this, we developed an assessment matrix. We described the ideal status after implementing all suggested measures, the current status, and the gap (necessary actions) between the two. Moreover, we assessed the availability and accessibility of the data that could support the achievement of the respective goals. The necessary data for seven out of sixteen measures, which data from a Bicycle Observatory could support, are currently available. The data are partly available for seven measures and currently not available for two measures. None of these data sets is currently entirely accessibly as open data; seven are partly provided as open data.

Table 2: Example for the assessment of action fields and measures defined in a local cycling strategy.

Action field	Ideal status	Current status	Required actions	Data available	Data accessible
Planning consistent main bicycle network	The main bicycle network is designed based on data on the existing infrastructure, bicycle traffic flows, as well as sources and destinations. The current situation before the measures are implemented is recorded and periodically compared with counting and tracking data in order to monitor the effect of the measures. In addition, user feedback is used for the qualitative evaluation of the measures	The main bicycle network of the city of Salzburg was designed by traffic planners in 2018. The planning was based on expert knowledge, an assessment of potential routes and an experimental simulation of effects.	Monitoring of bicycle traffic flows (dense network of cycle counting stations, processed trajectories) and analysis of user feedback.	Yes	Partly

Table 2 provides an example for how action fields in the cycling strategy Salzburg could be supported by data and insights from a Bicycle Observatory and to which degree necessary data are available and accessible.

4 Requirements for the establishment of a Bicycle Observatory

Since the contribution of a Bicycle Observatory to achieving strategic goals is evident, we identified the requirements for the establishment in a consecutive step. For this purpose, we launched an international web survey among experts (which is going to be published elsewhere) and conducted expert interviews with representatives of four institutions (two academic, two companies). From these inputs, we derived requirements in three different categories.

4.1 Requirements and recommendations with regard to data

We identified the accessibility of data as the major bottleneck for establishing a Bicycle Observatory. Thus, we recommend publishing all cycling-related data as open data for two reasons. Firstly, open data contribute to value creation in various application fields. This holds especially true for authoritative data, which are generated with public money anyway. Examples of this are road status data, counting data, or socio-demographic data. Secondly, open data usage leads to permanent quality control of the data and a subsequent improvement. In this context, we see huge potential for secondary data usage. Data that is initially generated for another purpose could be re-used in a Bicycle Observatory if it was made accessible. For instance, data from navigation apps, where the location is sensed in order to optimize the service for individual users, could be perfectly re-used in aggregated form for analysis purposes at a population level. Independent from the data source, the spatial and temporal resolution of available data is identified as being crucial for in-depth analysis. However, we found that most data are not available at the necessary resolution and quantity. In addition to data availability and accessibility, research gaps with regard to data integration became evident. For example, it remains unclear how crowdsourced trajectories (GNSS tracks) can be linked conceptually to stationary counting data. o the best of our knowledge, no method set exists beyond map matching trajectories and calculates correlation coefficients at selected locations. We, therefore, call for further research in the GIS domain in order to facilitate true integration, in addition to overlay analyses or visual inspections.

4.2 Requirements and recommendations with regard to data management

The effective handling of large amounts of data is only feasible with rigorous data management and the usage of data standards. Since data are integrated and linked based on geographical reference, we used data and service standards by the Open Geospatial Consortium (OGC). For managing the data, we recommend using a comprehensive data management plan (DMP), as for example, developed and provided as an Open Source template by Leitinger et al. (2020). This template describes data layers individually and contains core metadata, compatible with national and international metadata standards. For the operation of a Bicycle Observatory, the following information in a DMP is regarded as essential: geographical extent and coverage, update cycle, licence and privacy issues. On the basis of these four categories, the suitability of data for a Bicycle Observatory can be determined.

4.3 Organizational and legal requirements and recommendations

The organizational effort for establishing a Bicycle Observatory increases with the number of integrated data layers. This holds especially true if third-party data is used. In this case, data usage contracts need to be concluded, which is commonly associated with considerable effort. In addition to the data management, the success of a Bicycle Observatory very much depends on continuous conceptual, technical and content-related support. Regardless of whether a Bicycle Observatory is established within administrative bodies or outsourced to external service providers, a project owner is highly recommended.

With regard to privacy, we recommend not using individual data with direct reference to individual persons. Instead, anonymized and aggregated data are sufficient for the most common purposes of a Bicycle Observatory, where the observation of the entire system is key (and not the surveillance of individuals!).

5 Conclusion and outlook

Cycling data are essential for an evidence-based promotion of cycling mobility, as we revealed by a structured analysis of cycling promotion strategies. Although the number of sensors has increased at an unprecedented pace over the past years and huge amounts of data are being generated in the transport sector, we found that relevant cycling data are still sparsely available and accessible, respectively. A Bicycle Observatory would provide a suitable framework for integrating relevant data and provide them to decision-makers, planners and cycling communities. The framework of a Bicycle Observatory is adaptable and transferable. The POC, evaluated in this study, serves best activities at a local and regional level. However, the organizational and technological architecture can be employed for other scale levels and regions in the world as well. Against this backdrop, we call for further investments in data acquisition and provision and publish existing data to generate additional value through secondary data usage.

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