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Using Information and Communication Technologies to Facilitate Mobility Behaviour Change and Enable Mobility as a Service

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Abstract

Our mobility is responsible for substantial global greenhouse gas emissions and urban problems such as air pollution, usage of public spaces for infrastructure and parking, and congestion. Therefore, the transformation of our mobility towards sustainability is essential to achieve the sustainable development goals #11 (sustainable cities and communities) and #13 (climate action).

Mobility as a Service (MaaS) is a core concept for this transformation; however, there are still many open questions and challenges due to its novelty and complexity. The Empirical use and Impact Analysis of MaaS (EIM) project conducts a large-scale user study during the roll-out of a MaaS offer in Switzerland to gather empirical data that help to address and answer challenges and open questions.

Keywords: sustainability, mobility, MaaS, mobility behaviour change, ICT

1 Introduction

A large portion of our GHG emissions can be traced back to the movement of people and goods. In 2018, the transport sector was responsible for 24 % of the global GHG emissions (IEA, 2020), for 26 % of the GHG emissions in the European Union (Pilzecker et al., 2020) and for 32.4 % of the GHG emissions in Switzerland (Schilt, 2020). Tackling climate change, therefore, requires significant action in the transport sector.

Apart from the severe impact on climate change, the transport sector is linked to additional problems that are especially relevant for cities, such as air pollution, injuries, an increase of impervious cover for infrastructure (Gössling, 2020) and more traffic and congestion, which already results in high economic costs (Reed, 2019).

The primary source of these problems, including GHG emissions in the transport sector, is the private ownership of fossil fuel-based internal combustion engine cars (ICEV), therefore transitioning of the transport sector towards sustainability will have to focus on a sustainable alternative to ICEV based trips.

The most promising path for fast decarbonisation of the transport sector is the aggressive roll-out of battery electric vehicles (BEV) due to their significantly smaller environmental impact than ICEVs (Haasz et al. 2018; Cox et al., 2020). However, simply replacing ICEVs with BEVs leaves many challenges unresolved. Individual motorised transportation will still block large areas of public space for parking and infrastructure instead of using it for housing or recreational space. The problem of increasing traffic would persist.

In this paper, we will discuss the main strategies for the transition of individual human mobility towards sustainability in the sense of the Sustainable Development Goals (SDG) #11 "Sustainable Cities and Communities" and #13 "Climate Action". We thereby relate to the case study YUMUV, a novel Mobility as a Service (MaaS) platform in Switzerland and its associated research project Empirical use and Impact Analysis of MaaS (EIM), which studies its impact as an enabler of sustainable mobility.

2 MaaS key challenges:

MaaS is a mobility concept that integrates shared modes with public transport to facilitate intermodal travel (Reck, 2020). One goal of MaaS is to decrease private car ownership. This is a significant challenge as it requires individuals to undergo a significant behaviour change (Weiser et al., 2016; Raubal et al., 2020).

The integration of shared modes and public transport creates a high degree of complexity as many stakeholders such as mobility service providers (MSP), public transport operators and regulators need to synchronise to create a MaaS offer. The creators of these offers have a large degree of freedom along ten design dimensions such as the geography of the offer, the included modes, or the subscription cycle (Reck et al. 2020). Using this design space, several key factors are required for the resulting MaaS offer to be attractive to a broad audience:

- Attractive and easy pricing:
  Apart from an attractive price, the offer needs a comprehensible pricing structure, i.e., avoiding different pricing schemes for each mode of transport.
- Easy access:
  The user should be able to access all modes via a single gateway, such as a single app, instead of using a different gateway per mode of transport.
- Optimal availability and mobility options:
  The core of the MaaS package is the offered mobility. The desired modes of the user should be sufficiently available in space, time, quantity and sufficiently diverse to cover mobility demands in different situations.

The correct design of a MaaS offer concerning these factors is of utmost importance as they can potentially impact how a MaaS offer is used and its potential to decrease private car ownership. First evidence supports the claim that MaaS could decrease private car usage (Hensher et al., 2021); however, due to a lack of substantial behavioural data, it remains unclear how these design decisions influence the perception and the impact of MaaS and to what degree and how MaaS can change travel behaviour (e.g., mode choice, car ownership).

With these rather design-oriented questions, there are novel challenges regarding the technical realisation of a MaaS offer. The (large-scale) analysis of individual mobility behaviour poses the problem of combining heterogeneous data from various sources such as tracking data, context data or booking data all from different providers, different vehicles, and users. This is especially true for spatial tracking data, as there are many different possibilities to record a person's position with varying spatio-temporal granularity (e.g. GPS tracking data or public transport smart card data) (Miller and Goodchild, 2015). To answer questions about MaaS usage that help support the design of MaaS offers, the data must be collected, stored, filtered, integrated, and enriched with relevant context data.

One goal of MaaS is to cover the current mobility demand with less but optimised resources. This requires predictive knowledge about individual mobility behaviour and the available resources to solve tasks such as the optimal redistribution of mobility tools, optimised charging and maintenance cycles and the improvement of intermodal route recommendations. In the past years, machine learning has become the predominant tool for the prediction of human mobility (LUCA et al., 2020). However, most approaches assume mobility recordings to be independent and identically distributed or use simplistic 1st order Markov assumptions (Kulkarni et al., 2019), thereby omitting the information that lies in the highly regular structure of individual human mobility (Schneider et al., 2013). We, therefore, see great potential in expanding current work on the prediction to incorporate the spatio-temporal structure of human mobility and relevant context data to support a more efficient operation of MaaS.

3 study – The EIM project and YUMUV:

The EIM project is a collaboration between the Swiss Federal Railways (SBB) and ETH Zürich to fill the gap of lacking empirical data. For this, we designed a user study based on YUMUV[1] - a new MaaS offer that was introduced as a collaboration of SBB and the public transport providers in Zürich, Bern, and Basel.

YUMUV aggregates various mobility service providers (MSP) such as car-sharing, bike-sharing and shared e-scooters as a mobility platform and allows users to access all transport modes via mobility bundles – a subscription acting as an easy-to-understand pricing scheme for all MSPs. These bundles are city-specific, and in the case of Zürich, users can choose between a 30- or 60-minutes monthly subscription (shown in Figure 1 on the right), which allows using all modes of transport for a total of the respective minutes. The user can book different mobility options via the YUMUV app (shown in Figure 1 on the left), created in collaboration with trafi[2].

[1] https://yumuv.ch/en
[2] https://www.trafi.com/

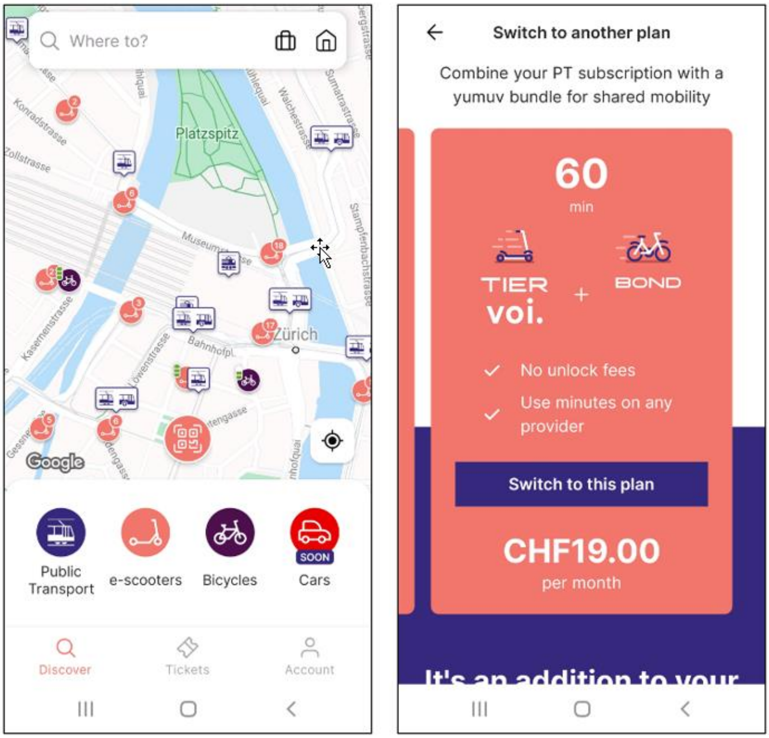

Figure 1: Two screenshots of the YUMUV android app. The left side shows the overview of available modes at Zurich main station, the right side shows one of the available bundles

The case study took place between August and October 2020 in the agglomeration of the city of Zürich and consisted of 71 persons in the treatment group and 417 persons in the control group. All participants were tracked for 3 month, and participants in the treatment group got access to a mobility bundle after 4 weeks.

During the study period, all participants recorded their movement using an app on their smartphone and provided labels for activities and modes of transport. The treatment group recorded booking data from the YUMUV app, and all users participated in a survey at the beginning and the end of the tracking period.

4 Takeaways from the data preprocessing phase

A crucial part of this project is integrating tracking data with context data for the subsequent analysis of the impact of MaaS on mobility behaviour and mode choice behaviour. In the following, we describe takeaways to keep in mind when designing a similar case study.

Label correction using different data sources:

In this study, all users were required to regularly label their recorded movement data with the mode of transport and activity categories in the tracking app. These labels are of great importance for the analysis of transport behaviour. However, they are often noisy as users might forget the labelling task or save effort and validate an incorrect label. During the preprocessing, it was very valuable that we could use the recorded booking data to validate and correct the user-provided labels. Even though it increases complexity, we recommend planning redundant tracking from different sources to reduce the noise in labels.

An early collection of context data:

The availability of shared modes in proximity plays a vital role in the mode choice for a trip. To analyse this influence, we started logging the locations of all relevant micro-mobility modes every 5 minutes in the study area during the study period. The resulting dataset has more than 600'000 entries per day and is used to calculate availability measures at the beginning of each trip.
We recommend planning the context data acquisition (e.g., by scraping) and the necessary infrastructure as early as possible in the project so that all context data is recorded in the same period as the tracking data and easily accessible.

Increase impact and reproducibility by contributing to open source projects:

Today, there are plenty of excellent open-source frameworks for processing and analysing spatial data. In this project, we used the open-source routing machine[3] for map matching, PostgreSQL[4] with PostGIS[5] extension for data management and relied on the many spatial Python libraries such as GeoPandas[6]. However, many niches, such as the processing of tracking data libraries, are missing or incomplete. We, therefore, decided to implement all suitable methods within the trackintel[7] framework and contribute to this open-source project. This increases code quality, reproducibility and the impact of this work as it allows others to benefit from it.

5 Outlook and expected contributions:

MaaS is expected to play a major role in the transport sector's contribution to achieving the sustainable development goals of climate action (#13) and creating sustainable cities and communities (#11). An essential next step to test the potential of MaaS to improve the sustainability of transport systems is the analysis of the impact of bundles on travel behaviour. Hopes are that multimodal transport bundles can reduce car usage in the short term and reduce car ownership in the long term (Mulley, 2017; Hensher et al., 2020; Ho et al., 2021). Substitution effects such as using shared cars instead of owned cars have to be carefully accounted for to measure the net effect of bundles on transport emissions (Reck et al., 2021).

[3] http://project-osrm.org/
[4] https://www.postgresql.org/
[5] https://postgis.net/
[6] https://geopandas.org/
[7] https://github.com/mie-lab/trackintel

Thus, comprehensive mobility profiles of trial participants are needed. The YUMUV trial allows analyses of these effects at unprecedented accuracy due to the broad scope of the collected data, including each participant's comprehensive mobility profile (tracking data, booking data, context data). Our trial set-up further includes a control group which is a first in studies aiming to analyse the impact of multimodal transport bundles.

The following step proceeding data preprocessing is to estimate YUMUV bundles impact on participants' mode choice using discrete choice models. In doing so, we expect to make a substantial contribution towards understanding the potential of MaaS to improve the sustainability of transport systems to inform policy-making towards more sustainable and integrated future mobility.

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