Smart Survey – A Turnkey Solution for Automatically Identifying Travel Modes and Trip Purposes of People with Smartphones[1]

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Extended Abstract

In many societies personal trips of people usually involve multiple travel modes, including passenger cars, buses, subway, walking, bicycle riding, etc. Different travel modes vary with respect to speed, acceleration patterns and other characteristics. Recognizing travel modes and trip purposes is critical to understand people's travel behavior and is vital for improving transportation planning, management and operations. The ever growing sensing capabilities of smartphones combined with their easy programmability, large market penetration rate, and effective distribution channels for third party applications have resulted in smartphones maturing into an effective tool for unobtrusive monitoring of human travel behavior. Identifying travel modes on smartphones allows interesting applications: smartphone-based mobility surveys, for example, automatically detect trip segments and document travel modes of respondents, allowing compilation of mobility profiles including carbon footprint. In addition, inferring activities of people, i.e. trip purposes further supports replacement of tedious manual writing of travel diaries at a new level. With knowledge of a person's travel mode, also targeted real-time information may be provided to the traveler, crowd-sourced real-time traffic information for travel modes is possible in which traffic speeds are aggregated from probes. Integrated e-ticketing apps for public transport

[1] We gratefully thank the company Neue Urbane Mobility GmbH, a subsidiary of the Wiener Stadtwerke Holding AG for their fruitful cooperation in performing real-world mobility surveys.

Published in "Proceedings of the 13th International Conference on Location-Based Services", edited by Georg Gartner and Haosheng Huang, LBS 2016, 14-16 November 2016, Vienna, Austria.

in a city or region would allow identification of times a user travels on public transport and charge fees accordingly.

Travel mode identification with smartphone sensor data is an active research field, see e.g. (Hemminki et al. 2013), (Shin et al. 2014), (Su et al. 2016), (Shafique & Hato, 2016). What is striking is that the development and validation datasets used for the publications are often rather limited. For example, the recent approach presented by Su et al. (2016) recognizes six modes, and their development dataset was obtained from five volunteers asked to travel in different modes, with durations ranging between 26 minutes and 46 minutes. Shafique & Hato (2016) also distinguish between six modes (but do not perform trip segmentation), where performance is based on 50 participants, some of which provided only a single day of travel. The approach in (Hemminki et al. 2013) distinguishes between four transport modes based on accelerometer data, and was developed on 150 hours of transportation data from 16 individuals. The work in (Montoya et al. 2015) requires a transport network infrastructure (OpenStreetMap) and General Transit Feed Specification (GTFS) data to distinguish six modes. Their validation data for the 87 journeys in Paris was not self-reported by the unknown number of travelers, but annotated by a single person "familiar with the Paris transportation system". The complexity of their algorithm is stated as 0.1 CPU seconds per journey second, which is prohibitive for practical applications.

We present and demonstrate smart survey, a readily available software solution for smartphone-based multi-modal trip reconstruction distinguishing eight travel modes (walking, bicycling, driving a car, driving a motorbike, taking a bus, tramway, subway, train). The principle is as follows: a software app continuously runs on a smartphone in the background and analyzes and records smartphone sensor data for trip starts, and collects and records network location data during trips. The client software frequently transfers the recorded data from the smartphone to the server via available wireless data standards. The server software analyzes the transferred sensor data of the smartphone for trip segments and classifies transport modes into eight classes (Widhalm et al. 2012), (Nitsche et al. 2014). A web application allows editing and correcting the trips (travel mode, activities) by the user (*Figure 1).*

The solution has the following distinguished features:

- The system automatically recognizes *eight travel modes* – walking, bicycling, driving a car, driving a motorbike, taking a bus, tram, subway, train.
- The concept captures *activity based mobility by identifying trip purposes semi-automatically* (the related system *modalyzer* (https://www.innoz.de/en/node/88 does not represent the activity concept)

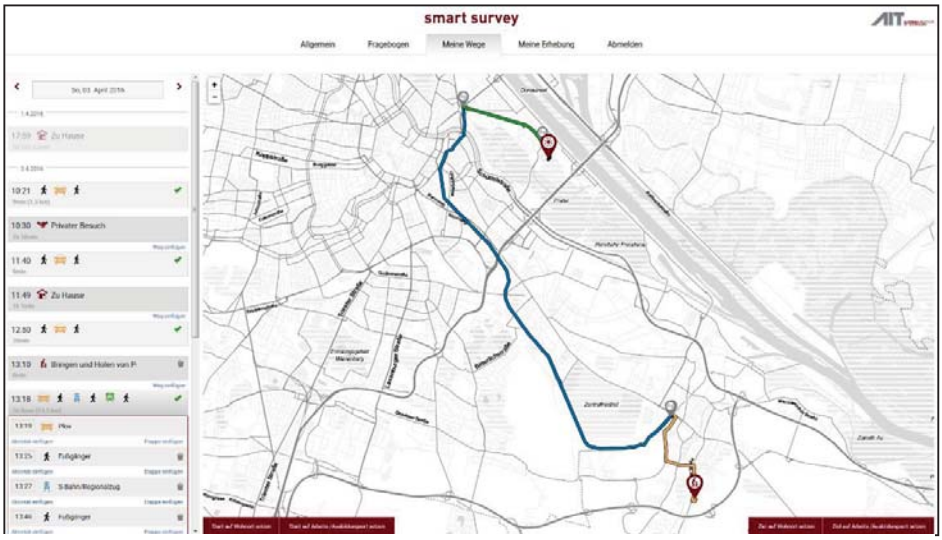

Figure 1. Screenshot of the web application allowing correction and validation of the inferred trip data

- The performance was evaluated on comprehensive real-world trip data captured by more than 300 respondents participating in mobility surveys, self-reporting the correctness of the automatic trip reconstruction on the smart survey web application during several weeks. The solution was extensively tested between June and August 2016 by 123 customers of the public transport provider in Vienna recording their daily multimodal travel behavior. The survey produced more than 7800 trips with a total length of more than 75.000 km and 7875 hours. 82% of the trips were confirmed by the respondents.
- The best results for trip reconstruction can be achieved by exploiting transport network data such as OpenStreetMap or General Transit Feed Specification (GTFS), yet the solution also runs without supplementary GIS data (e.g. in regions without extended underground lines).

The showcase at the LBS conference venue demonstrates the easy setup with QR-Codes and provides demonstration of the smart survey web application.

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