An efficient approach to create agent-based transport simulation scenarios based on ubiquitous Big Data and a new, aspatial activity-scheduling model

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Abstract

Agent-based transport simulation models are a particularly useful tool to analyze demand-oriented transport policies and new mobility services, which have both gained significant attention lately. Since travel diaries, a traditional source to create the transport demand in agent-based transport models, are often hard to procure and not policy-sensitive, alternative approaches to creating travel demand representations for simulation scenarios are sought. In this study, a particularly efficient approach based on Big Data and a new, aspatial activity-based demand model with comparatively low input data requirements is established. Home, work, and education locations are informed based on mobile-phone-based origin-destination matrices. Other activity locations are modeled within the scope of the coevolutionary algorithm of the agent-based transport model, which is also responsible for finding suitable travel options of the modeled individuals. As a result, a comparatively lightweight process chain to create an agent-based transport simulation scenario is established, which is transferable to other regions.

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Keywords: Agent-based transport simulation; transport model; big data; cell-phone data; activity-based demand models

MATSim is an agent-based transport simulation framework. The individual traveler (agent) is the central unit of analysis and maintained during the whole modeling process. Each agent has one or more daily activity-travel patterns that they try to optimize by applying modifications along different possible choice dimension (e.g. changing routes, changing modes of transport). As agents are maintained during the whole process, dependencies and constraints between different trips or trips and activities are inherently resolved. This makes the simulation framework particularly interesting for the analysis of novel, often more demand-oriented transport policies like user-stratified restrictions (e.g. environmental zones with distinction by vehicle emission class), tolls or user pricing or the analysis of novel transport services (e.g. MaaS or autonomous taxis) and technologies (e.g. electric vehicles).

A classic data source to create daily activity-travel plans is a travel survey. Based on a set of trip diaries of the study region, the plans of all members of the population can be created. However, travel diaries have the disadvantage

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that all information taken from diaries is by definition not sensitive to policies. Furthermore, trip diaries are normally available for only a very small fraction of the population. Also, in many places, travel diaries are subject to strong usage restrictions because of data privacy regulations, which often results in a strong coarsening of all spatial information.

In this study, an efficient approach to creating a transport simulation scenario with a high policy sensitivity and low input data requirements is described. It circumvents the issues related to more traditional input data types and explores the use of Big Data as partial substitutes. The approach is put into practice as a prototype for the metropolitan area of Zurich in Switzerland. As illustrated in Fig. 1, the approach consists of the following four steps:

First, a representation of population of the Zurich metropolitan area is created based on the STATPOP dataset, a full population census of the Swiss population.

Second, origin-destination (OD) matrices from mobile-phone data records are used to derive work and education locations for each member of the study area’s population. For the present project, a mobile-phone network operator provided 24 hourly origin-destination matrices, which record movements of people on the municipality level on average working days on a month-by-month basis.

Third, to model activity sequences and activity durations, the new and comparatively data-parsimonious activity-based demand model (ABDM) actiToppis used. actiTopp is based on the concept of utility-based regression models and, like MATSim, implemented as an open-source software in Java, which facilitates model integration significantly. Both the modeling capabilities and the input data requirements of actiTopp are lower than those of other activity-based demand models. actiTopp does neither have a notion of travel nor space, but models pure activity sequences with corresponding durations. Trips between subsequent activities are unspecified beyond the fact that they take place. Locations are not modeled. On the input side, actiTopp only requires age, gender, occupation status, number of cars in household, number of children in household, home location setting, and commuting distance to work or education (if applicable), which have been provided via steps 1 and 2.

Fourth and finally, the locations of discretionary activities (e.g. shopping or taking part in leisure activities) need to be modeled. While the agents’ home locations are known based on population input data and locations of mandatory activities (i.e. attending work and education) have been derived from mobile-phone-based OD matrices, the locations of discretionary activities are unspecified until now. For this task, Horni’s location choice approach is used, which fixes (freezes) the agent- and location-specific randomness inherent in the decision (as seen from the perspective of the modeler) such that a realistic representation of choices of secondary locations emerges when allowing agents in the simulation to switch locations while trying to improve their daily activity-travel behavior by MATSim’s coevolutionary algorithm. As such, discretionary activity location choice can be included in MATSim’s demand adaptation.

To evaluate the results of the Zurich prototype application of the new scenario creation approach, an existing MATSim simulation scenario for the Zurich metropolitan area, developed at the Institute for Transport Planning and Systems at ETH Zurich, is used as a reference for a scenario-to-scenario comparison. While the model based on the new approach shows plausible travel patterns and correct average participation rates, the representation of trips to discretionary activities should be improved in future research.

The new approach is comparatively easily transferable to other regions. Only highly standardized input data sources are used and those very sparingly. The mobile-phone-sourced OD matrices that where used to derive work and education locations can be assumed to exist in almost any location worldwide. While actiTopp was used for activity scheduling, all other decisions, including the choice of location for discretionary activities, are modeled within MATSim’s coevolutionary approach, which improves the approach’s policy sensitivity.