Large-scale microscopic travel behavior modeling

The well-known four-step process consists of the steps trip generation, trip distribution (= destination choice), mode choice, and route assignment. The four-step process, at least in its traditional form, has many problems with modern issues, such as time-dependent effects, more complicated decisions that depend on the individual, or spatial effects at the micro (neighborhood) scale.

An alternative is to use a microscopic approach, where every traveller is modelled individually. This typically starts with a synthetic population of individuals, adds activity patterns and activity locations to each individual, lets the synthetic travelers choose their mode, and ends with a route assignment procedure.

One way to achieve this is to start with the synthetic population and then work the way “down” towards the network assignment. This typically results in activity-based demand generation (ABDG) models (e.g. [1, 2, 3, 4]), which sometimes do and sometimes do not include the mode choice, but typically end with time-dependent origin-destination (OD) matrices which are then fed to a separate route assignment package. The assignment package computes a (typically dynamic) route equilibrium, and feeds the result back as time-dependent zone-to-zone travel impedances. When feedback is implemented, then the activity-based demand generation model recomputes some or all of its choices based on those travel impedances (e.g. [5]).

As has been argued several times, this type of coupling between the ABDG and the traffic assignment leaves room for improvement [6, 7]. In particular, it can be argued that route choice is also a mental demand decision, and in consequence the decision to include route choice into the assignment model rather than into the demand generation is arbitrary. Problems immediately show up if one attempts to base a route choice model in a toll situation on demographic characteristics – the demographic characteristics, albeit present in the ABDG, are no longer available at the level of the assignment. Similarly, in all types of intelligent transport systems (ITS) simulations, any modification of the individuals’ decision beyond route choice becomes awkward or impossible to implement.

An alternative is to keep the individuals that were generated in the ABDG also throughout the assignment. This has the following advantages:

- Both the route choice and the network loading can be related to the characteristics of the synthetic person. For example, toll avoidance can be based on income, or emissions calculations can be based on the type of vehicle (computed in an upstream car-ownership model).

- Additional choice dimensions besides route choice can be included in the iterative procedure of assignment (also see [8, 9]).
In analogy to evolutionary computation, it is plausible to interpret the synthetic travellers as individually optimizing agents. For this, they need a function to optimize, sometimes called a fitness function. In the context of travel behavior research, it is plausible to equate this with the utility function: every synthetic traveller tries to optimize his/her own utility function. The utility function needs to be commensurate with the choice dimensions that are considered: If additional choice dimensions are included, the utility function typically needs to be expanded. While, for example, route choice only looks at the generalized cost of the trip, departure time choice also includes schedule delay cost, mode choice compares the generalized costs between different modes, location choice includes the attractiveness of the possible destination, etc.

Zurich application

In this paper, we will report how to make such an approach work, using the metropolitan area of Zurich as an example (as a sub-region of an “all-of-Switzerland” scenario [10]). Since detailed census and microcensus data was available, the “behavioral boundary conditions” (synthetic population, activity patterns, primary activity locations) were taken directly from these data sources, taking primary activity destination choice (work/education location) directly from the census, and drawing activity patterns conditional on demographic attributes. Secondary activity locations, mode choice, route choice, and time choice were generated based on heuristics.

From there on, the synthetic travellers were allowed to adapt mode, route, and times in order to individually maximize an externally given utility function. That utility function minimally includes penalties for time spent travelling, rewards for time spent performing activities (e.g. [11]), and opening time constraints of facilities. The utility function was originally selected based on expert knowledge, but is now in the process of being changed into one derived from discrete choice models.

The results are compared to real world data, in particular to about 159 counting stations in the Zurich metropolitan area. Importantly, it is found that adding choice dimensions usually improves the quality of the results. This is far from obvious, since in principle adding choice dimensions gives the model more dimensions in which it can drift away from a good starting condition (obtained from good data).

Since we have traffic counts to validate our model, we naturally prefer such modeling assumptions that generate a good “fit” with respect to these counts. Until recently, the 4-step-process was ahead of our approach in this regard because its simple mathematical structure allowed for the development of a broad variety of (more or less automated) demand calibration procedures. In this article, however, we present the first real-world application of a novel methodology for the calibration of demand microsimulators from network conditions such as traffic counts. The theory for this was developed over the last couple of years [12, 13]. Although the approach can be used for virtually arbitrary measurements and choice dimensions/parameters, this paper will demonstrate how hourly link counts can be used to systematically adjust simulated travel behavior in order to better represent the measurements. Preliminary results indicate that the average error of hourly link flows can be reduced to below 10%, while at the same time keeping the integrity of the behavioral interpretation intact.

References


