Traffic assignment models in large-scale applications - DTU Orbit (10/12/2018)

Traffic assignment models in large-scale applications

Transport models are becoming more and more disaggregate to facilitate a realistic representation of individuals and their travel patterns. In line with this development, the PhD study focuses on facilitating the deployment of traffic assignment models in fully disaggregate activity-based model frameworks. In the correct integration, such frameworks allow realistic representation of individual-specific household interactions, time-space constraints and preference structures. Individual trips can also be evaluated on a detailed address-to-address level and aggregation biases are avoided. The study focuses on large-scale applications and contributes with methods to actualise the true potential of disaggregate models. To achieve this target, contributions are given to several components of traffic assignment modelling, by (i) enabling the utilisation of the increasingly available data sources on individual behaviour in the model specification, (ii) proposing a method to use disaggregate Revealed Preference (RP) data to estimate utility functions and provide evidence on the value of congestion and the value of reliability, (iii) providing a method to account for individual mis-perceptions in the choice set generation for complex multi-modal networks, and (iv) addressing the difficulty of choice set generation by making available a theoretical framework, and corresponding operational solution methods, which consistently distinguishes between used and unused paths. The availability of data is essential in the development and validation of realistic models for large-scale applications. Nowadays, modern technology facilitates easy access to RP data and allows large-scale surveys. The resulting datasets are, however, usually very large and hence data processing is necessary to extract the pieces of information relevant to the analysis at hand. Manual processing of the datasets are typically not possible, and it is therefore necessary to have methods available which in some automated ways clean and prepare the datasets for the desired use. The present study proposes a fully automatic post-processing procedure that combines fuzzy logic- and GIS-based methods to process raw individual-based GPS data with no additional information required from the respondent. The method comprises (i) identifying and removing non-trips and trip legs without proper mode classification; (ii) identifying and removing non-trips and trip legs without proper mode classification; (iii) classifying nontrips such as scatter around activities as trip legs, and (iii) identified the correct mode of transport for more than 90% of the trip legs. These results are very promising, especially when compared to results generated by existing algorithms. The results highlight the potential of the method proposed and the possibility to use individual-based GPS units for travel surveys in real-life large-scale multi-modal networks. Congestion is known to highly influence the way we act in the transportation network (and organise our lives), because of longer travel times, but the reliability of the travel time also has a large impact on our travel choices. Consequently, in order to improve the realism of transport models, correct understanding and representation of two values that are related to the value of time (VoT) are essential: (i) the value of congestion (VoC), as the VoT varies with traffic conditions and hence congestion multipliers reflect the complexity of driving conditions when more vehicles are present on the road, and (ii) the value of reliability (VoR), as the VoT relates to the predictability of travel time and the repeatability of the travel experience. Congestion and reliability highly influence each other, but so far only studies based on Stated Preference (SP) data considered concurrently congestion and reliability variables. The PhD study contributes to the state-of-the-art by presenting a new approach to estimate the VoR and VoC based on RP data. The approach applies a mean-variance model that considers congestion and reliability concurrently. The model was applied to GPS data and it successfully estimated mixed Path Size Logit models, using a sample of 5,759 observations in the peak period and a sample of 7,964 observations in the off-peak period. Results illustrated that the value of the different time components (free-flow, congestion, and reliability) and the congestion multiplier were significantly higher in the peak period. This seems reasonable because of possible higher penalties for being late and, as a consequence, possible higher time pressure. Results also showed that the marginal rate of substitution between travel time reliability and the total travel time, considering the average congestion level, did not vary across time periods and traffic conditions. The study highlights the potential of exploiting the growing availability of observations of actual behaviour to obtain estimates of the (monetary) value of different travel time components, thereby increasing the behavioural realism of largescale models. vii The generation of choice sets is a vital component in route choice models. This is, however, not a straightforward task in real-life applications, as: (i) there are almost infinitely many alternatives, but large choice sets are computationally demanding or even unfeasible; (ii) congestion effects need to be considered; (iii) the choice sets should contain all relevant alternatives, including the observed route if one such is available, while leaving out unreasonable and redundant routes; and (iv) the attributes of the alternatives should vary enough to facilitate consistent parameter estimates if the choice sets are to be used for choice model estimation. The PhD study contributes to the state-of-the-art by proposing and validating a simulation-based choice set generation method for general networks. The validation used 5,131 observed route choices collected on the highly complex large-scale Greater Copenhagen area public transport network. By evaluating alternative ways to specify the stochasticity and the level of this, it was found that the level of stochasticity should be high to induce high coverage and statistically efficient parameter estimates when the choice sets are used for estimation. The level of stochasticity should, however, be introduced with parsimony, as significant increases translate into generating redundant and counter-intuitive paths with no considerable improvement in coverage. Adding heterogeneity across travellers improved the results considerably, and induced coverage levels up to a very high 98.8% at an 80% overlap threshold. This shows the potential of the method proposed as well as the importance of accounting for as much individual heterogeneity as possible, as models become more disaggregate. A revisit to the original conditions underlying the Stochastic User Equilibrium (SUE) has led to the realisation that the difficulty of specifying the choice set is related to the assumption on the distribution of the mis-perceptions. It is the commonly adopted assumption that the distributed elements follow unbounded distributions which induces the need to enumerate all paths in the SUE, no matter how unattractive they might be. The Deterministic User Equilibrium (DUE), on the other hand, has a built-in criterion distinguishing definitely unused from potentially used routes, but the cut-off in terms of cost differences is strict. Based on this, two new model frameworks and corresponding equilibrium formulations are
introduced. Both models combine the strengths of the SUE and DUE by permitting the consistent combination of (i) equilibrated non-universal choice sets and (ii) flow distribution according to random utility maximisation theory. One model allows distinction between used and unused routes based on the distribution of the random error terms, while the other model allows this distinction by posing restrictions on the costs of used/unused routes. Generic path-based solution algorithms and convergence measures are introduced for the model which seemed the most straightforward to apply given its connection to existing RUM-based models (the one adding restrictions). Different variants of the algorithms were validated for the MultiNominal Logit and Path Size Logit choice models on the Sioux Falls as well as the large-scale Zealand network. A novel consistent convergence measure verified extremely fast and well-behaved convergence to an equilibrated solution on non-universal choice sets (across different congestion levels, scale parameters and step-sizes). The composition of the choice sets were validated by comparison to real-life route choices of 16,618 individual trips on the Zealand network. The applications were also very successful in reproducing observed link counts. The solution algorithms are thus computationally attractive, and the solutions and the underlying framework are behaviourally realistic. This causes the new framework and solution algorithms to be highly attractive to apply as models become more disaggregate. Summarising, the PhD study has given contributions to several of the components that concern the estimation and solution of traffic assignment models in large-scale applications. Through this, the PhD study has successfully facilitated the consistent integration at the disaggregate level across traffic model parts. This means that the true potential of the activity-based models can be actualised.

General information
State: Published
Organisations: Department of Transport, Traffic modelling and planning, Rapidis ApS
Contributors: Rasmussen, T. K., Nielsen, O. A., Prato, C. G., Frederiksen, R. D.
Number of pages: 345
Publication date: 2015

Publication information
Publisher: Technical University of Denmark, Transport
Original language: English
Electronic versions:
PhD_Thesis_ThomasKRasmussen_print.pdf
Research output: Research › Ph.D. thesis – Annual report year: 2015