Investigating the minimum study area size for an activity-based travel demand forecasting model

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Background

As an alternative to the four-step model of travel demand, the activity-based approach has currently been given more and more attention by transportation researchers and has resulted in the development of a number of practical models, such as TRAMSIMS, RAMBLAS, CEMDAP, FAMOS, and ALBATROSS. Since the approach focuses on the complete activity behavior patterns and adopts a holistic framework considering the individual interactions and spatio-temporal constraints, it explicitly reveals the inability of the conventional trip-based approach and can be used to address many policy issues and their impact, such as land use, energy consumption, emission, safety, teleworking, and congestion pricing, attributed to the accessibility to the enriched activity-travel data.

Although its usefulness in transportation planning and forecasting has been widely recognized, one of the practical limitations of applying most of the current available activity-based models is their computation time, especially when large amount of population and detailed geographical unit level are taken into account. For instance, in the FEATHERS (Forecasting Evolutionary Activity-Travel of Households and their Environmental RepercussionS) framework, an activity-based micro-simulation modeling framework currently implemented for the Flanders region of Belgium, it takes approximately 16 hours for a single model run based on the 10% fraction of the study area population at the most disaggregated geographical level of detail. If the population fraction is increased to 50%, it will take nearly two days to generate the basic prediction data set. Moreover, if multiple model runs are required due to the consideration of stochastic error derived from the micro-simulation approach, the computation time will be magnified dramatically, which makes the real-time application of the model particularly difficult or even impossible to realize.

Research question

In order to reduce the computation time when applying an activity-based model, one possibility is to reduce the size of the study area. Indeed, since it is often the case that only a small territory (e.g., a municipality) rather than the whole region or country is the focus of a specific and local project, a relatively small study area surrounding the target territory needs to be taken into account. In doing so, the computation time of the model could be effectively saved. The question then becomes: how to determine the minimum size of the study area without deteriorating the model accuracy.

Methodology

In this study, we investigate the minimum size of the required study area for each of the 327 municipalities (also defined as Superzone) in Flanders (Belgium) using the FEATHERS framework. More specifically, for each particular Superzone, one more zone (which could be any predefined geographical unit) with the shortest centroid distance to the target Superzone is added each time. Then, the travel demand (i.e., the number of trips) of both departing mode and arriving mode between the added zones and the target Superzone is computed, and the difference with that from the whole Flanders is used to indicate the accuracy of the new study area. More zones are added until the predefined accuracy requirement is reached. The obtained study area is thus the minimum size needed for the travel demand predictions of the target Superzone. The centroid distance between the last zone that was added to the study area and the target Superzone can be considered as the minimum radius of the study area surrounding this Superzone.

Results

In the experiments, all of the 327 Superzones of Flanders are studied and the minimum radius needed for each of these Superzones is investigated using a 90% level of accuracy. The results are shown in Fig. 1.

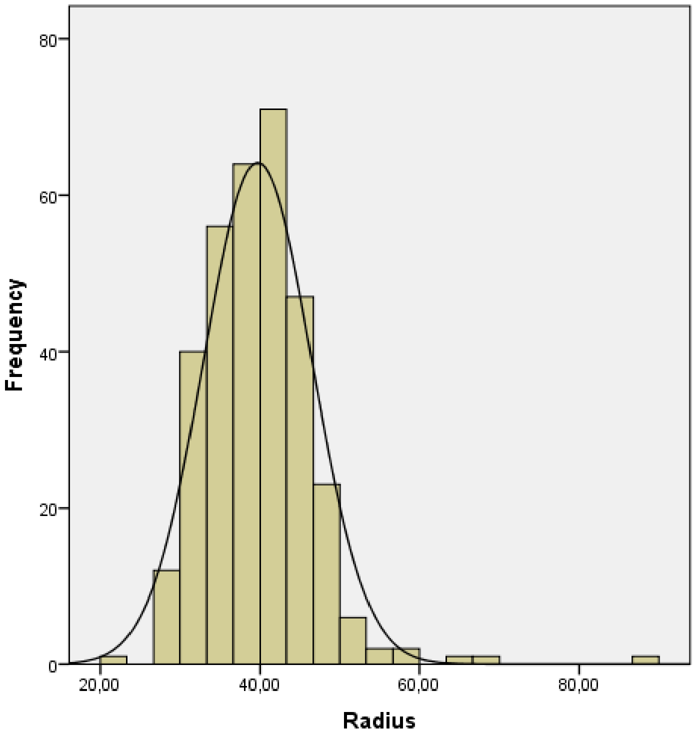

Fig. 1 The distribution of the minimum radius needed for 327 Superzones of Flanders

The average of the minimum radius required for each of the 327 Superzones is 39.70km with the standard deviation of 6.77km. Given the area of the whole Flanders is 13709.24km^2, the size of the study area surrounding specific municipalities could be reduced to a great extent, and therefore the computation time of the currently implemented activity-based model inside FEATHERS would be reduced remarkably.

Summary

The requirement of large computation time is currently one of the most important practical issues of applying activity-based models. In this study, we investigated the minimum size of the study area needed for each of the 327 municipalities of Flanders using the FEATHERS framework. The results show that when only a particular territory is considered in a specific project, it is possible to rebuild a relatively small study area for this target territory. Running the model in such a new study area will not deteriorate the model accuracy, but will improve the model's operational efficiency significantly and will also facilitate the further development as well as the dissemination of this modeling framework.