Modeling residents external activity-travel in an activity-based model using FEATHERS

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1 Background

Travel demand modeling has evolved from the traditional four-step models to tour-based models which eventually became the basis of the advanced Activity-Based Models (ABM). ABM considers the complete activity-travel pattern of individuals living in the region. However, the activities that are scheduled outside the modeling region results in residents' external activities and trips which are modeled separately as internal-external trips.

At present, the majority of the ABM does not model external travel by allowing the destination choice of activities only within the modeling region, e.g. DAYSIM, ABM within SimMobility (Singapore) and FEATHERS (Flanders, Belgium, and Seoul, South Korea) (Adnan et al. 2015; Bellemans et al. 2010; Bowman and Bradley 2006). The trips resulting from these activities are fed in the route assignment along with internal-external trips obtained from other models. Such an approach may result in the following deficiencies:

- Overestimating trips and activities within the region by assigning all residents' activities within the study area while completely disregarding the residents' external activities and trips.
- A *double representation* of residents' external trips at the route assignment stage i.e. 1) from the ABM where external activity-travel of individuals is considered as internal trips and 2) through the output from the external trips model.
- Inability to test policy applications on resident's external travel because these are estimated outside the scope of the ABM.

Expanding the size of the study area to minimize the external travel does not help either as this practice increase model development and data collection efforts significantly (synthetic population of a larger study area needs to be developed). Few ABM such as ALBATROSS, and ADAPTS consider the outside area through the additional zone(s) in the destination choice model (Arentze and Timmermans 2004; Auld and Mohammadian 2012). However, the size of these external zones is very large as compared to the zones within the study area. Due to this, travel times and cost of trips between the study area and the surrounding region will be inappropriate and, therefore, sub-models within ABM that requires these inputs may not perform well.

2 Aims

The aims of this research are:

- To propose a framework to model residents external trips within the framework of activity-based models
- To apply the proposed framework in a study area
- To evaluate the model performance

3 Proposed Framework

This section describes a framework to model external travel as part of the complete activity-travel schedule in FEATHERS (an ABM model). This is realized by including the locations outside the study area (in the form of Catchment Area) in the destination choice models (Figure 1). The catchment area is defined such that it includes the farthest location mentioned by any individual in the household travel survey. Since major changes are implemented in destination choice model it is further described in detail.

Destination choice models

The destination choice models in FEATHERS are built using decision trees and use a multi-level decision hierarchy to specify the location of an activity. At the first level, superzones (defined at the municipality level) are shortlisted on the basis of points of interest (POI) density and the distance band. Then, from this limited range, a municipality is randomly chosen followed by the choice of subzone (each municipality is further disaggregated into numerous subzones depending on the size). A similar methodology is applied to assign locations to both primary and secondary activities. However, all decisions related to the primary activity are made first and then incorporated into the destination choice model of secondary activities.

It is imaginable that the detailed land-use information, which has been obtained for the study area, may not be available for the catchment area subjected to the limited resources and even unavailability of the information such as in case the study area is defined at the country level. Therefore, two top-level models are introduced in the current framework each for the primary and the secondary activities which intent to identify if the activity will take place in the study area or the catchment area. If the activity will take place in the study area then complete information is used, otherwise, only the variables formulated from open source platforms are used in estimating sub-models. Land-use characteristics such as type, timings, area, and employment and transport network attributes such as travel time, transit availability, price, and frequency can be easily obtained from open source platforms for developing destination choice models and mode choice models respectively.

The top-level model for the primary activity is built upon individual and household level characteristics and the land-use information obtained from the open source platforms such as OpenStreetMap (OSM) (OpenStreetMap contributors 2017) and Google API (Google Developers 2017). In addition to these attributes, the top-level model for secondary activities also takes into account individual’s schedule decisions which have been already adopted. The open source land-use data is found similar to the commercial building information obtained from official data sources (Statbel 2017), as shown in Figure 2.

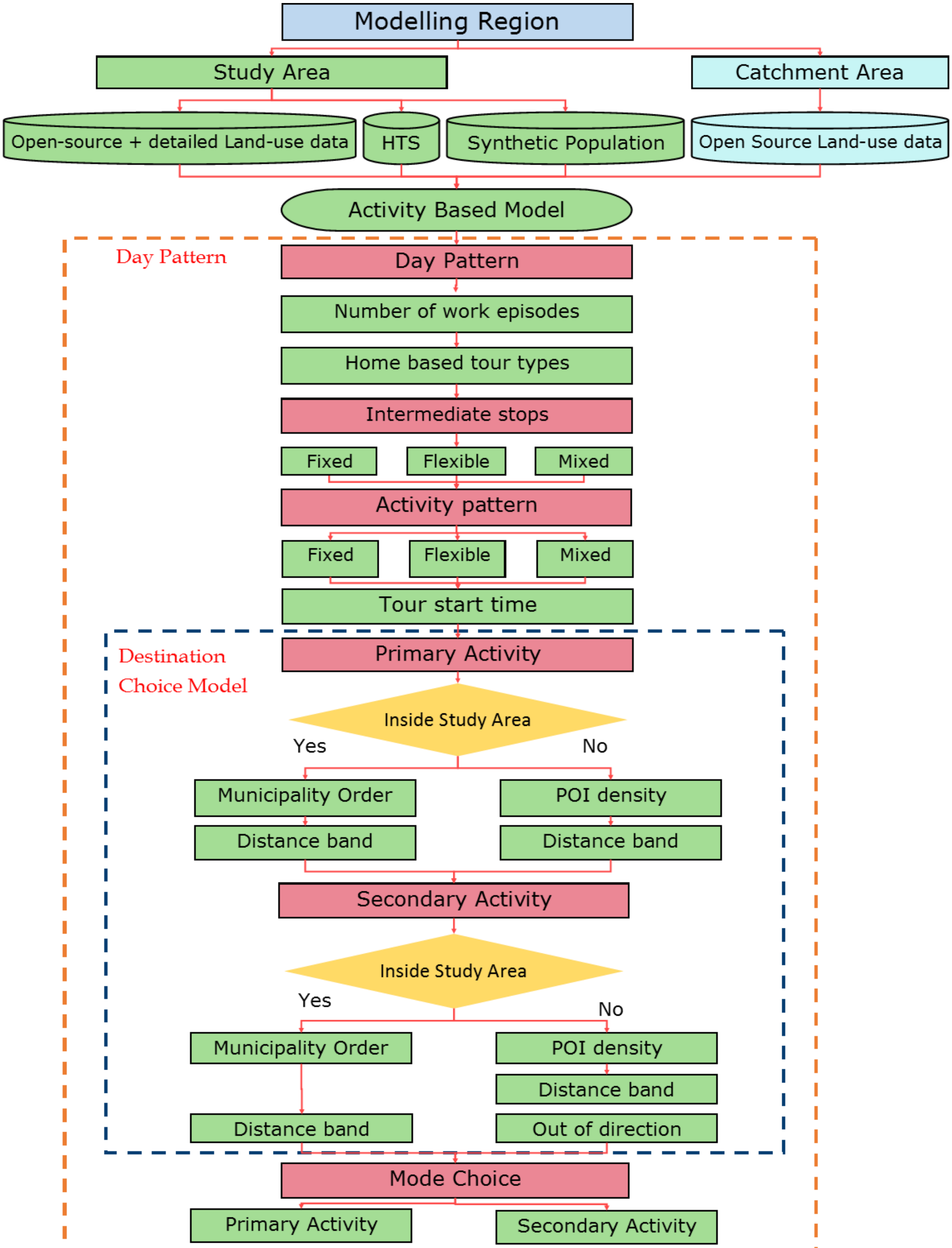

Figure 1: Proposed framework

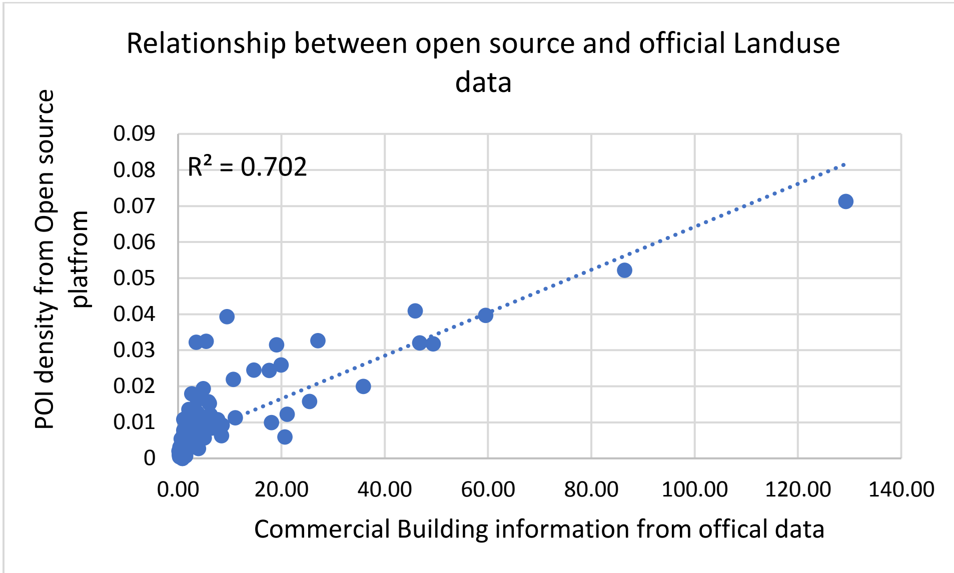

Figure 2: Relationship between open source and official land-use data

4 Results

The above-described changes are adopted in ABM FEATHERS which is operational for complete Flanders (Dutch speaking part of Belgium). The changes include modifying the decision trees, re-estimation of the location-choice model and running FEATHERS for a smaller region – defined as the study area. In order to test the proposed methodology, Leuven region and an extended region around Mechelen are defined as the study area. Leuven region has an area of 1,168km^2 and a population of around 0.5 million. Furthermore, there is a considerable fraction of individuals that commute to Brussels (which is near Leuven), thus, making it an interesting case to check the proposed framework. Similarly, Mechelen is located between two attractive regions; Antwerp (in North) and Brussels (in South) thus producing a large share of external travel. At the south of Flanders is the Wallonia region (French-speaking part of Belgium). Only 1.4% of individuals commute to Wallonia from Flanders due to the language barrier (Horckmans 2017), which is quite low to train and test the model. Therefore, Wallonia region is not included in FEATHERS.

Several indicators related to the activity-travel are applied to measure the consistency between the observed and the predicted movements (Table 1). No significant difference has been found between observed and predicted values in both regions except one criterion thus validating that fact the overall activity pattern remains consistent with this approach.

Figure 3 illustrates the observed and predicted desire lines in the extended Leuven region. Clear trip attractions towards major attractors can be observed in both the figures, however, there are differences present in smaller zones. This may be due to the limited training dataset of fewer than 1000 individuals in both the cases.

5 Conclusions

The results suggest the validity of the proposed framework that makes the application of ABM easier on smaller regions as well. These regions are adequate enough to have a travel demand model of their own and irrespective of the percentage of individuals that travel outside the study area to perform their daily needs. Therefore, the methodology described shall be helpful in developing an ABM for smaller regions. Future research shall focus on determining the minimum sample size required to apply ABM in a small study area and achieve the desired results.

Table 1: Statistical analysis of observed and predicted travel behavior

Criteria	Leuven Region	Mechelen Region
	P-Value*	P-Value*
Percentage of trips by each travel mode	0.50	0.01
Types of transport mode use	0.50	0.50
Average time spent travelling	0.00	0.50
Types of activities performed	0.50	0.50
Number of in-home activities	0.50	0.50
Number of out-of-home activities	0.00	0.50
Number of total activities	0.50	0.50
Percentage of time spent on each activity	0.47	0.50
Tour complexity**	0.50	0.16
Activity start time	0.50	0.50
Activities performed in CA	0.50	0.50

* P- values greater than 0.1 describe no difference at 10% confidence interval; ** tour complexity is defined as the number of activities performed in a tour from 1 to 5;

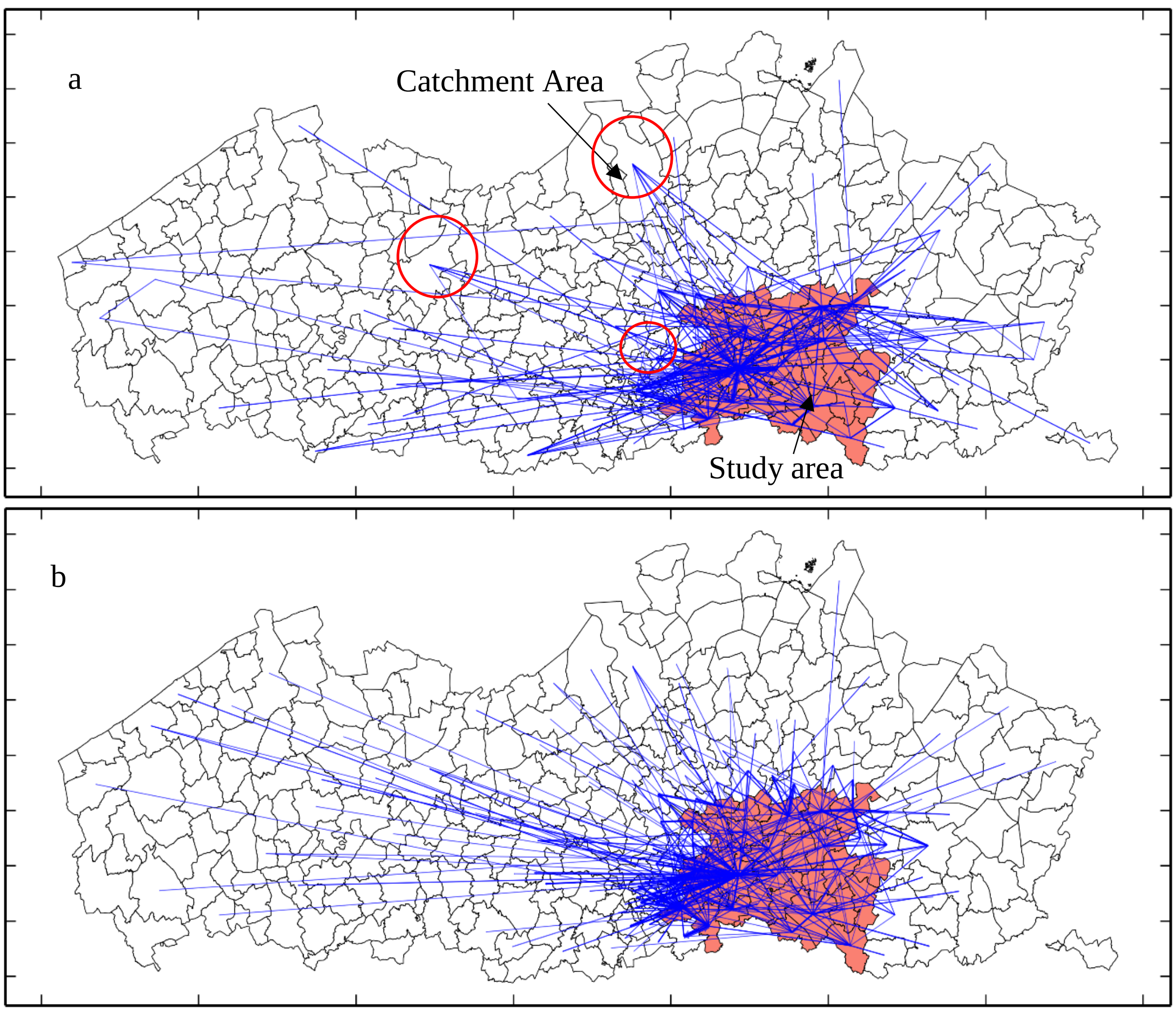

Figure 3: (a) Observed desire lines of individuals in Leuven district at superzone level; (b) predicted desire lines of individuals in Leuven district at superzone level

References

Adnan, M., Francisco C Pereira, Carlos Miguel, Lima Azevedo, Kakali Basak, Milan Lovric, Sebastian Raveau Feliu, et al. 2015. "SimMobility : A Multi-Scale Integrated Agent-Based Simulation Platform." *Transportation Research Board (TRB) 95th Annual Meeting*, 1–18.

Arentze, Theo A., and H. J P Timmermans. 2004. "A Learning-Based Transportation Oriented Simulation System." *Transportation Research Part B: Methodological* 38 (7): 613–33. doi:10.1016/j.trb.2002.10.001.

Auld, Joshua, and Abolfazl Kouros Mohammadian. 2012. "Activity Planning Processes in the Agent-Based Dynamic Activity Planning and Travel Scheduling (ADAPTS) Model." *Transportation Research Part A: Policy and Practice* 46 (8): 1386–1403. doi:10.1016/j.tra.2012.05.017.

Bellemans, Tom, Bruno Kochan, Davy Janssens, Geert Wets, Theo Arentze, and Harry Timmermans. 2010. "Implementation Framework and Development Trajectory of FEATHERS Activity-Based Simulation Platform." *Transportation Research Record: Journal of the Transportation Research Board* 2175 (1): 111–19. doi:10.3141/2175-13.

Bowman, John L., and Mark Bradley. 2006. "Activity-Based Travel Forecasting Model for SACOG."

Google Developers. 2017. "Developers Site." https://developers.google.com/maps/documentation/business/places/.

Horckmans, Marc. 2017. "Waalse Werknemer Gaat Sneller Taalgrens over Dan Vlaamse Collega." *Express Business*. https://nl.express.live/2017/01/26/waalse-werknemer-gaat-sneller-taalgrens-dan-vlaamse-collega/.

OpenStreetMap contributors. 2017. "Https://planet.osm.org."

Statbel. 2017. "Land Use in Belgium since 1990." https://statbel.fgov.be/nl/themas/leefmilieu/grond/bodemgebruik#figures.