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Incorporate Pedestrian Modeling with a Microscopic Integrated Land Use and Transport Model for an Urban Region

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1. Introduction

There is growing awareness of the need to plan for sustainable urban mobility, including improvements to the quality of walking environment, developing supportive land use patterns, and other investments to promote pedestrian travel. According to the sustainable urban development plan for the Munich region, more trips are expected to shift from motorized transports to non-motorized modes (City of Munich, 2006).

Walking, as an active transport mode, can reduce energy usage, reduce the environmental issues, such as air and noise pollution resulting from motorized transports, and improve overall public health through reductions in diseases related to obesity and cardiovascular conditions. Previous studies have shown a significant influence of land use planning on walking behavior (Gehrke and Clifton, 2014). To achieve a higher share of walking and more sustainable urban transport use, there is a need for better planning tools that are sensitive to pedestrian needs. A detailed land use and transport model integrated with pedestrian travel can help provide better predictions of mode shifts due to socioeconomic development. Furthermore, such a model is useful for policy analysis, including investments in transportation infrastructure, land use planning, assessment of safety and health outcomes, and evaluation of environmental impacts.

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However, integrated land use and transport (ILUT) models have not kept pace with the progress in research on pedestrian travel. In existing operational ILUT models, walk mode is usually omitted or combined with cycling as one non-motorized mode (Waddell, 2002). For example, the microscopic ILUT model SILO-MITO-MATSim (hereafter referred to as the Munich Model) is a microscopic integrated land-use and transport model (Moeckel and Nagel, 2016). At this moment, walking is represented insufficiently in the Munich Model to analyze pedestrian travel behavior. In the framework, the mode choice model estimates the share of non-motorized travel at a coarse spatial resolution and subsequently drops those trips from further analysis. This is caused in particular by the differences between the spatial resolution needed for walking transport and vehicular modes and the barriers to collecting data on pedestrian behaviors. Therefore, this paper proposes an integrated model that incorporate a pedestrian model with the Munich Model to overcome this shortcoming in the ILUT model.

2. Methodological approach

To improve the estimation of walking behaviors (e.g. walk share and walk destination choice) in the ILUT model, we link the model of pedestrian demand MoPeD (Clifton et al., 2016) with the Munich Model. MoPeD provides the pedestrian modeling framework in this work and makes use of model components estimated with data from the Portland, Oregon metropolitan area in the USA. It is an aggregated trip-based urban travel demand model for pedestrian travel. It follows the traditional four-step model, but it changes the spatial unit from transportation analysis zones (TAZs) to a finer-grained scale called pedestrian analysis zone (PAZ) defined by an 80m×80m grid cell, which can better represent the pedestrian behavior. Also, mode choice between walk and non-walk trips is done before destination choice, which has improved the trip length frequency distribution of walk trips.

The Munich Model is a model suite with three modules, including the land use model SILO (Moeckel, 2017; Ziemke et al., 2016), the travel demand model MITO (Moeckel et al., 2019), and the transportation simulation MATSim (Horni et al., 2016). The land use model SILO provides a synthetic population and simulates demographic changes, household relocation and real-estate development. MITO is a microscopic travel demand model that generates trips for every household, which are then passed on to MATSim for trip assignment. The Munich Model uses 5,000 gradually-sized zones as its spatial unit, which were designed to capture vehicle trips rather than relatively short walking trip.

The spatial units chosen to model the pedestrian scale for this research depends on the relevant data available for Munich. Land cover data for Munich region is nested into 100m×100m raster. With such small PAZ scale, the study area of the Munich model will be covered by approximately 2,000,000 PAZ equivalents. Given the computational burden, we define the PAZ scale in this research is 200m×200m raster.

Figure 1 shows the working process of the integrated model. Firstly, MITO provides trip decision/trip generation at person level to MoPeD. In the MoPeD module, walk trips are generated and then fed back to MITO.

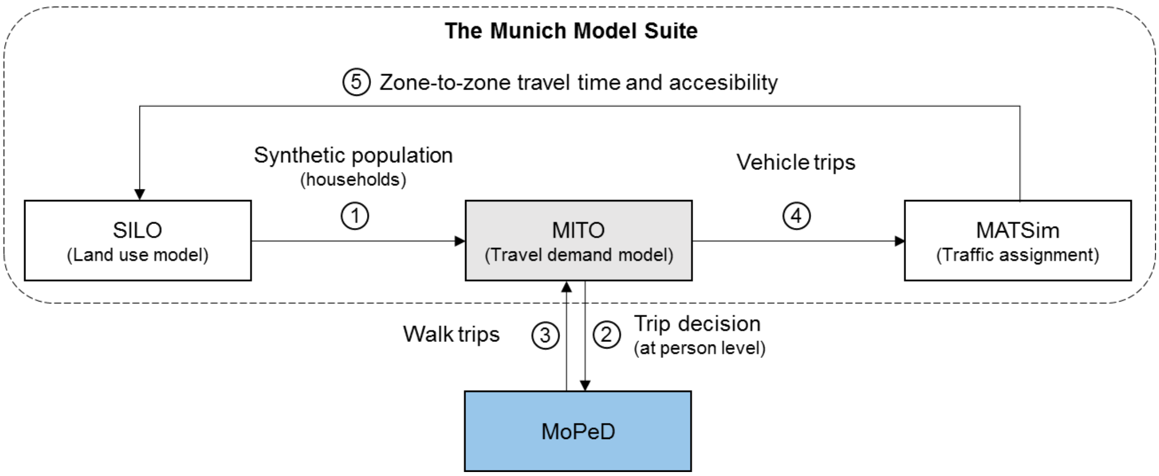

Fig. 1: The framework of the Integrated Land Use and Transport Model incorporating the pedestrian model

Figure 2 gives an overview of the integration of MITO and MoPeD. Agent-based trip generation is modeled in MITO. As household and job locations in MITO are simulated at a micro-location level (in x/y coordinate), it is flexible to aggregate locations to any spatial resolution. Then, travel time budgets including pedestrian and non-pedestrian trips are calculated based on household attributes. After that, trip data are fed to MoPeD to do the following transport decisions at the PAZ level. PAZ level measures of the built environment are used in both the walk mode choice and the walk destination choice models. Given the mandatory nature of work and education trips, those trips are modeled first. Work and school locations are stored in the synthetic population, hence, no destination choice is necessary here for mandatory trips. The corresponding travel time is subtracted from the travel time budget of every household. Then, destination choice for walk trips are modeled for non-work and non-education purposes, and their travel time is subtracted from the travel time budget as well. Mode choice for mandatory trips includes travel distance as an explanatory variable, as the destination of those trips is already given in the synthetic population. For discretionary trips, the trip length is unknown at this stage. Then, non-walk trips are aggregated to the coarser 5,000 gradually-sized raster cells of the Munich model. The remaining travel time budget is used to select destinations of non-walk trips. Mode choice and selection of the preferred trips arrival times are modeled in MITO for all non-walk trips. The integrated model is calibrated using 2008 Mobilität in Deutschland survey data.

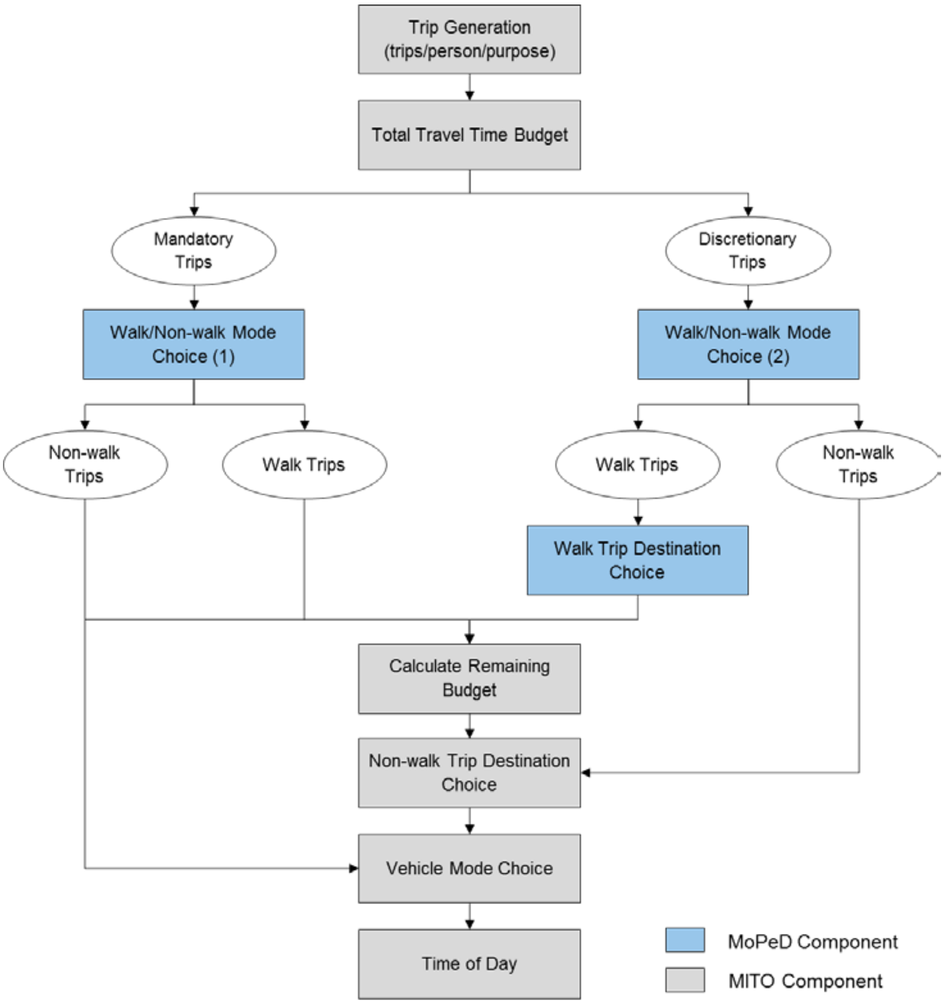

Fig. 2: The framework of the integration of MoPeD and the Munich Model

Pedestrian travel behavior might be better represented by integrating MoPeD into the ILUT model. For example, more walk trips might be captured in the highly-populated areas. More short-distance trips might be accounted for pedestrian behavior, which could improve the trip length frequency distribution of walk trips. More accurate prediction of walking behavior could also give us a better picture of vehicle traffic flows and road network saturation. To explore whether the integrated model can better represent walk behaviors, the following model outcomes will be compared spatially between the base model (the Munich Model) and integrated model (Munich model + MoPeD): 1) Walk share; 2) Walk trip length frequency distribution; 3) Vehicle travel time from MATSim.

Moreover, a better representative of pedestrian behavior in ILUT model can also improve the sensitivity of model to various policy and demographic changes related to walking, including investments to improve walking environment, land use development policy and residential relocation. As a result, this paper will apply the integrated model to different transport and land use scenarios to verify its ability and sensitivity in reflecting the impact of policies and demographic changes on walking behavior.

3. Conclusions

A comprehensive land use and transport simulation model will be developed in this paper to evaluate walk and non-walk transport demand at a regional level. Walking behavior will be better represented in ILUT model. Possible transport-related measures that considers pedestrian demand will be investigated and their sensitivity will be examined in the case study. Most importantly, it will be possible for the first time to explicitly explore the impact of a separate walk model. While MITO includes walking in a model that was built for vehicular travel, MoPeD has been designed to capture travel behavior of pedestrians. This research will allow for an honest assessment how relevant it is to account for pedestrians separately in an urban model.

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