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Seoul activity-based model: An Application of Feathers Solutions to Seoul Metropolitan Area

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Abstract

As a study area, Seoul metropolitan area in Korea, where has been experiencing transportation problems including congestions and emissions, currently needs an alternative policy measure at the individual level, instead of large scale infrastructure constructions. Even though some researches based on an activity-based approach dealing with an individual travel behavior have been conducted in Korea, none of them used a simulation framework. Considering a genuine activity-based transportation demand forecast, there is no better option but to introduce the activity-based simulation framework. Among several activity-based simulation frameworks, Feathers will indeed be applied into the study area because it is the most viable and suitable simulation platform for that area in terms of a similar spatial dimension. Although, the application for the study area is possible on Feathers, there are potential problems, including the prohibition of using individual and household data in census, an inconsistent administrative unit in Korea and inappropriate Flemish figures and patterns for the study area. To overcome these problems, IPF for synthesizing population and a comparative study of Flemish and the study area will be applied in this study. Moreover, we plan to integrate an agent-based model with the TDM research in order to complement the activity-based model by predicting an adapted daily schedule to an individual circumstance.

Keywords: Seoul metropolitan area, Transportation demand model, Activity-based model, Agent-based model, Feathers.

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1. Introduction

A study on travel behavior has been essential for understanding a transportation phenomenon. The travel behavior is affected by spatial patterns and human decision making processes because trips are occurred by the segregation of residential area, workplace and other activity places, and people tend to select trip components, such as when, how and with whom, by the decision making processes considering spatial and temporal constraints. Hence, a transportation demand measure (called TDM in this study) to study the travel behaviors becomes an important methodology in transportation study.

TDM is classified into two ways; macro and micro approach. The former macro modeling approach is referred to as four-step model (called FSM in this study) which is based on a origin-destination. FSM is a primary tool for estimating a travel demand and the performance of a transportation system, which is typically defined at a regional or sub-regional scale [3]. On the other hand, an activity-based model as the latter micro approach predicts on an individual level where, when and how specific activities take place (e.g. work, leisure, shopping, etc.). Although both approaches generate partially same outputs with a zone-to-zone traffic volume and an OD matrix, there is a different perspective of trips and a simulation purpose. For example, although FSM ignores linkages misstate people's responses to travel demand policies [9], activity-based model (called ABM in this study) generates activity-travel schedules with individual's activities and trips. Indeed, Kitamura (1996) suggested the ABM approach offers a better framework for the analysis of TDM, advantages of this approach summarized to daily behavior, realism, induced demand [7].

As a matter of fact, this study aims to implement the ABM framework for the TDM approach in Seoul metropolitan area, where is called as SMA in this study, Korea, where has been experiencing transportation problems, such as traffic congestion, accidents, increase of a fuel cost and CO2 emissions. As the prerequisite process, this paper mainly focuses on figuring out potential problems and finding a solution for those problems in the implementation of the framework in the SMA. Thus, following section briefly introduces some of the frameworks, and then section 3 describes Feathers and a case study in Flanders, Belgium. Section 4 discusses the procedure of the TDM approach using Feathers. Finally, section 5 concludes with summary and future research.

2. Activity-Based Models

For the last few years, several activity-based model frameworks has been developed in transportation. Most of the frameworks, for example, AMOS, ALBATROSS, and Feathers, are based on the assumption that people seems to use context-dependent heuristics. Firstly, AMOS is based on the two significant modules, one is Household Attributes Generation System and the other is the Prism-Constrained Activity Travel Simulator [6]. The model is an useful approach for policy impact assessment, but it does not represent a generalized approach [5]. Next, ALBATROSS is the most comprehensive and only operational computational process model [1]. It can be considered as a rule-based system that predicts activity patterns based on the human decision-making process. Feathers is a kind of activity-based travel demand measure platform that defines a travel demand as derived activities to achieve individual goals [4]. In the following section, more details of Feathers will be explained.

3. Feathers

Feathers was developed to study the activity-based TDM approach in Flanders by IMOB in Hasselt University, Belgium [2]. In a data point of view, the Feathers requires a somewhat detailed information about household, demographic factors and characteristics. Thus, a trip-based survey called OVG (Onderzoek VerplaastingsGerdarg Vlaanderen) that include demographic, socioeconomic, household and

trip-making characteristics of 8,800 persons selected by a random sample from a national register was applied for the activity-based TDM approach. In addition, population data is also needed with the number of household members, annual income, vehicles, and so on. Therefore, a synthetic population data set was produced because getting individual data in Flanders is not allowed from administrative registers for privacy reason. A geographic unit inside the Feathers framework is defined by means of a hierarchy of three geographical layers on the top of each other, which are a superzone (all municipalities in Flanders), a zone (administrative units at one level lower than municipalities) and a subzone (virtual areas based on homogeneous characteristics).

As for a modeling output, Feathers predicts a daily activity-travel schedule for each individual. But it differs across seven weekdays, and day-dependency of schedules is available in minutes. Besides, Feathers allows for one to study a scenario analysis, for instance, to what extend an increase in Electric Vehicle market affects on individual activity-travel schedules? Moreover, Feathers implies that projected travel is derived within the general framework of the daily activities undertaken by households and persons, including in-home activities, intra-household interactions, time allocation for activities, and many other aspects pertinent to activity analyses in terms of an individual's aspect. The figure 1 and 2 depict a daily activity pattern for persons who come from a specific origin location (Hasselt in Flanders) and an individual's socio-demographic pattern, respectively.

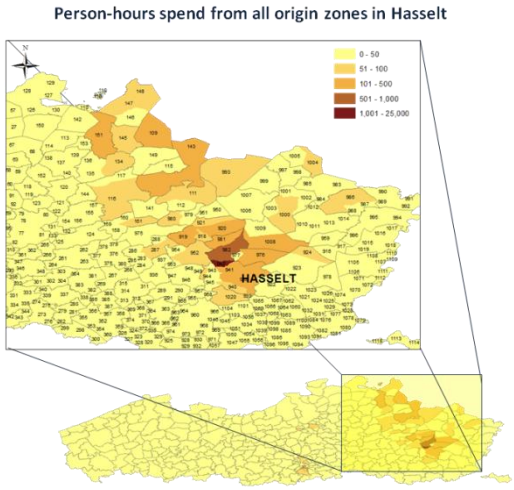

Fig. 1. Feathers output(1) – Daily activity-travel schedule (Hasselt in Flanders)

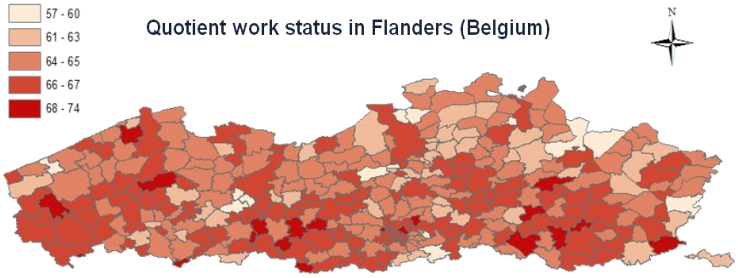

Fig. 2. Feathers output(2) – Daily activity-travel schedule (in Flanders)

4. Application to Seoul Metropolitan Area

4.1. Study Area

As study area, Seoul metropolitan area consists of three regions; Seoul, Incheon and Gyunggi. Total population is 23,616,000 (49% of total: 48 million) and has been increasing for each 5 years (21 million in 2000, 22 million in 2005 and 23 million in 2010). Since a paved roadway occupancy ratio presents 25% and commuters' public transport modal choice ratio is 45%, it can be seen that the transportation infrastructures are well equipped. The following figure 3 and 4 display the study area and network data, respectively. Moreover, KOTI (Korea transportation institute) collects the SMA network data from local governments and related institutions, and generates the theme maps of transportation with the collected data, which is called as Korea transport database [8]. The figure 3 and 4 illustrate two maps describing the study area and its network, respectively.

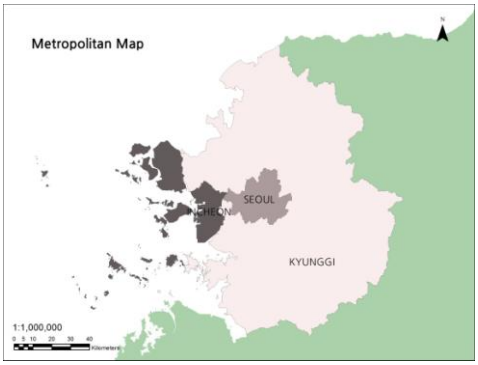

Fig. 3. Seoul Metropolitan Map

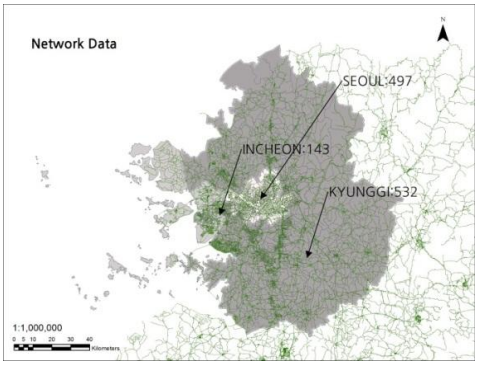

Fig. 4. Seoul Network Map

According to Seoul metropolitan household survey report (2009), total number of trips is 55 million per a day. Regarding an activity, people act 'being at home' type with around 45% in a day, which is the most frequent activity in SMA. Next, 'work' and 'school' types take account of almost 19% and 13% of total activities, respectively. For a trip, approximately 30% of population in SMA travels by walk, and 24% and 23% of population use their own vehicle and a bus as a public mode, in reseptive. Also, another public mode subway is used for around 11% of population. Here an interesting point is that around 6% of population takes a carpooling as a trip mode. The figure 5 and 6 show the ratio of activity type and trip mode, respectively.

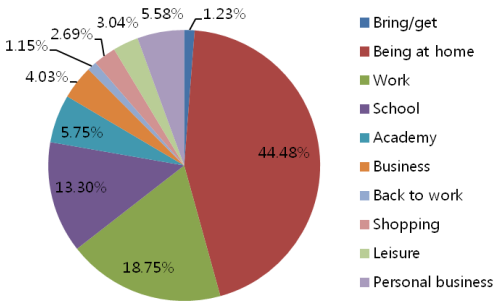

Fig. 5. Percentage of activity type

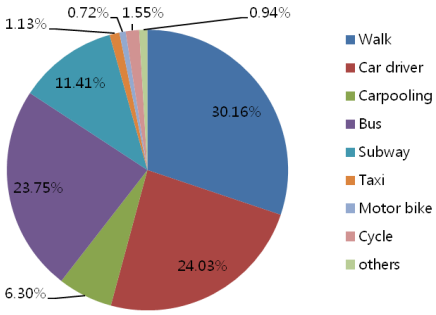

Fig. 6. Percentage of trip mode

4.2. Application process

As the preprocessor of the application, input data should be satisfied with the data requirement of Feathers. Firstly, Seoul metropolitan household survey collected by KOTI is used as a trip-based observed data to induce the heuristic rule of a decision tree on Feathers. Based on the rule, census is used to product the individual daily schedule for the whole population in the study area. As environment data, network and administrative division data are applied to the TDM research.

There are potential problems in using the data in Korea. One is that only 10% sampling census involves rather detailed socio-demographic data, such as economic activities, migration, fertility, elderly, and housing welfare, and the rest describes only brief information of the population. The other comes from the different hierarchical structure of a zone system. In Korea, a zone data is based on an administrative division, SI, GU and DONG, which are the highest, the second and the lowest level of the division, respectively. While SI and DONG are compatible with superzone and subzone in Feathers, respectively, GU is relatively too large to analyze the TDM research. Hence, TAZ (traffic analysis zone) can substitute for the GU as zone on Feathers because it consists of several subzones which have homogenous characteristics.

4.3. Application results and agendas

FSM has been used to study the TDM in SMA, so far. Nevertheless of some advantages, there are a few drawbacks when using FSM in SMA. For example, the FSM cannot catch up the alteration of the traffic pattern over time because a correlation factor in the simulation model should be faced with the problem of a low confidence according to the change. Therefore, Feathers is an invaluable alternative to the FSM because it allows to study the TDM according to varied transportation environment, that is a scenario analysis. Moreover, it forecasts not only a zone-to-zone aggregate traffic volume for each trip purpose and mode choice but also trips derived from an individual daily activity schedule projected by Feathers. In addition, new transportation policy is testified by means of simulating how to impact on individual activity-travel trips. Lastly, travel demand forecast in a long-term perspective is feasible for micro-scope approach based on a social phenomenon, like an aging society.

As mentioned above, there exists a lot of challenges for the application of Feathers in SMA, Korea. First, since using individual census data is not allowed because of a privacy problem, a synthetic population method like IPF (Iterative proportional fitting) is used to generate population data with an observed activity-travel data. Second, using geographical layers have to be carefully handled with a consistency because administrative one in Korea has been often altered over time. Lastly, since figures and patterns specified in Flanders are used for Feathers, it is inevitable to define a feasible configuration of the study area through the comparative study of two regions.

In addition to the application of Feathers, we have another agenda on the TDM research in SMA. The existing activity-based model has a limit on that it cannot analyze the change in a decision-making process based on a particular situation of each person, such as working overtime and long commuting, because a daily activity-travel schedule is estimated by defining a heuristic rule between an individual background and activity-travel behavior using an observed data which includes a small sample size and an aggregated result. Hence, a microscopic research based on each person, not aggregated into a zone, is needed to predict an individual activity-travel schedule. Therefore, we plan to apply an agent-based model, which simulates the process of an agent’s decision-making in a given specific circumstance, to the activity-based TDM research. The integrated TDM research with the agent-based model allows us to predict a microscopic traffic demand by producing a daily activity-travel schedule adapting to an individual situation.

5. Conclusions

The main purpose of this study is to apply Feathers to the activity-based TDM approach in SMA, Korea. Since there has been no experience of the application of the activity-based TDM approach in Korea, several challenges can be easily expected in the study area, for instance, the limitation of using individual and household data and the inconsistent geographic units over time and the infeasible Feathers configuration for the study area. To solve the potential problems, several solutions, IPF and a comparative study, will be applied to this study.

The application of Feathers will play a crucial role not only in an alternative policy measure for the TDM approach, but also in an optimal solution for transportation problems by new transportation circumstance in Korea.

Acknowledgements

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