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Regimes in social–cultural events-driven activity sequences: Modelling approach and empirical application

Theo Arentze, Harry Timmermans *

Urban Planning Group, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands

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ABSTRACT

In this study we propose and apply a Bayesian-network model to predict and analyse the factors that influence activity-travel sequences that are triggered by social–cultural events. The study is motivated by the intention to examine the wider context in which activity-travel decisions are made and to model such decisions under longitudinal time horizons. We assume that social events trigger a series of interrelated activities and corresponding trips. Data about events and related activities are collected using a month-diary and involving a large sample of households in the Eindhoven region, The Netherlands. A learning algorithm is applied to derive a Bayesian-network model from the event diary. The results show that indeed many travel choices are influenced by particular events, that these influences vary by socio-demographic variables and that the learned Bayesian-network model is able to represent these interdependencies among all these variables. We demonstrate how the model can be used to predict event-driven activity-travel sequences in a micro-simulation.

1. Introduction

The field of activity-based analysis and modelling has truly matured over the last decade. A large body of descriptive and analytical studies has emerged that focus on particular aspects of activity-travel patterns. Furthermore, much progress has been made regarding the development of comprehensive models. Recently, the first fully operational, comprehensive activity-based models have become available and are currently tested and applied in daily transportation planning practice. For example, Vovsha et al. (2004) report the development and application of discrete choice based models in several locations in the United States, such as Portland, New York City, San Francisco County and Columbus, Ohio. Similarly, CEMDAP developed by Bhat and his co-workers (2004) as a set of loosely integrated advanced econometric models has found application in Texas. Likewise, FAMOS (Pendyala et al., 2005) and its predecessor PCATS (Kitamura and Fujii, 1998) have been applied in Japan and Florida. ALBATROSS (Arentze and Timmermans, 2000, 2005) has received a stamp of approval by the Dutch Ministry of Transport. Finally, the more recent TASHA model (Miller and Roorda, 2003) is getting close to application.

While certainly a lot of effort is still required to move activity-based models to practice, the academic community can start addressing a wider set of questions. One of the limitations of current activity-based models is their focus on a typical daily pattern. Most models are cross-sectional in nature and are not really based on a behavioral process representation. There is a need to describe, analyze and model activity-travel decision-making for a wider time horizon of multiple weeks in particular to better represent activity-generation processes.

In an attempt to model activity-generation dynamically in a multi-week time frame Arentze and Timmermans (2006, in press) have suggested a needs-based theory. This theory assumes that activities are conducted to satisfy certain needs. The time it takes for a need to recover and the scarcity of an individual's time, together, determine the timing and duration

* Corresponding author. Tel.: +31 402473315; fax: +31 402438488.
E-mail address: m.v.d.sande@tue.nl (H. Timmermans).

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choices for an activity. Furthermore, due to a many-to-one relationship between activities and needs, positive and negative generation effects exist between activities. Using needs as a conceptual basis is similar to the theoretical orientation underlying TASHA (Miller and Roorda, 2003; Miller et al., 2005; Roorda et al., 2008) and MATSIM (Meister et al., 2006). The main difference is that our theoretical framework has some explicit mechanisms that endogenously account for the dynamics of activity-generation due to changing needs.

The present study considers the influence of social–cultural events. A needs-based theory of activity-generation can explain the existence of particular rhythms in multi-week activity patterns. Individuals and households are, however, also part of a social system with its institutions, regulations and culture. The social system has a major impact on the organisation of society and therefore also on how particular needs are organised over time. Belonging to a social system means that individuals and households organise their life in accordance with social norms, rules and expectations, which means that it requires a set of interrelated activities to maintain the social system. Examples are religious events such as Christmas, celebrations of anniversaries and holidays. We have therefore argued that activity-based models should gradually be incorporated into event-based models in an attempt to incorporate the larger decision context and wider time horizon into the modelling effort, thereby enriching the modelling of transport demand (Arentze et al., 2006).

We assume that these events trigger a series of interrelated activity sequences. Individuals engage in activities to make preparations (before the event), implement the event itself and to take care of the event aftermath (after the event). This notion is akin to Axhausen's concept of a project as a set of coordinated activities tied together by a common goal or outcome (Axhausen, 1998; Miller, 2005), albeit positioned differently in the sense that our focus is on socially and culturally triggered events.

The purpose of the present study is to develop and apply a methodological framework for an event-based analysis and modelling of (multi-day) activity-travel patterns. In specific we propose a Bayesian belief network to empirically derive and represent the causal relationships between activity and travel choices in the context of specific events. The structure and parameters of a Bayesian-network model are derived from event data using a learning algorithm. The resulting model reveals regimes in activity-travel sequences triggered by social–cultural events and can be used to predict these sequences, as a function of demographic and situational variables. We apply the proposed methodology to an event diary dataset collected for this purpose from a large sample of households in Eindhoven, The Netherlands. To our knowledge, it is the first empirical study examining such sequences. The paper is structured as follows. First, we describe some key concepts and the Bayesian belief network technique to model the assumed processes. This is followed by a summary of the data collection and a discussion of the results of a model-based analysis. The paper is completed with some conclusions and a discussion of potential avenues of future research.

2. Concepts and approach

2.1. Definition of an event

We define events as those occasions or activities in the life of an individual that are special in that they fall outside the domain of regularly recurring activities conducted by the individual to fulfil his/her basic needs at person or household level. Even when they occur on a regular basis, events are salient in the perception of the individual and they tend to break the routine of every day life. An event does not only disturb the daily routine on the day it happens. Typically, an event requires also that certain activities are implemented before and after the event to make necessary preparations and take care of the aftermath of the event. An example of an event is the celebration of a person's birthday. Such events typically entail activities before and after the event; before, to make sure that food and drinks are available for the guests and the house is tidy and, after, to dispose of the litter and bring the house back in an orderly state after the guests have left.

Based on this notion, we define an event as any activity or occasion that falls outside an individual's daily or weekly routine of activities and typically (but not necessarily) entail preparing activities and/or aftermath activities before and after the event. Many events thus defined originate from an individual's drive to participate in social and cultural life and are preplanned. However, our definition does not exclude events that are unplanned or even unforeseen, such as for example a sudden hospital intake. The decisive characteristic is that the event is not part of what the person considers to be the activities of everyday life. Note that an implication of this definition is that what counts as an event for one person does not need to be an event for another person. Table 1 shows a classification of events which illustrates the concept and which we used in the survey (explained below) to assist respondents in recalling relevant events. As the list indicates, most classes of events are social in nature, i.e. involve gatherings of people to celebrate a special occasion related to a person (e.g., birthday) or a community (e.g., thanksgiving). However, events may also have another primary purpose such as for example recreation (e.g., a day-out), health (e.g., a therapy) or maintenance (e.g., a house job). Events tend to be diverse with respect to duration. Events such as celebrations, sports tournaments, festivals, etc., often start and end within the time frame of a day. The event classification shown in Table 1 is limited to that category. Multi-day events, e.g. holidays, are also considered events, although they are left out of consideration in the empirical application.

2.2. Structure of the proposed event-based model

The results of an exploratory analysis of event data (Arentze et al., 2006) indicate that events are quite diverse with respect to the extent their temporal regimes are influenced by socio-economic variables or relatively fixed by existing insti-