Time Geography for Activity Modeling with GPS Tracking Data

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Introduction

Global positioning systems (GPS) and related technologies have made it feasible to collect dense tracking data in an efficient way. Several studies in the U.S. and Europe have collected GPS tracking data for transportation related studies (Wolf, Guensler and Bachman 2001, Wolf, et al. 2004, Schönfelder and Axhausen 2004). Although dense GPS tracking data, with explicit spatial and temporal components, can add significant values to activity-based transportation studies, use of GPS tracking data also bring up new research questions and challenges that need to be addressed.

Activity-based Approach and GPS Tracking Data

Unlike the conventional trip-based models, the activity-based approach considers the travel/activity pattern as the basic unit of analysis to help us gain a better understanding of travel behavior (McNally 2000). GPS tracking data provide useful information on *where* and *when* people or vehicles are located. GPS data per se do not tell *what* and *why* people and vehicles are at particular locations during particular time periods. In other words, GPS can help us collect data of movements rather than activities. To analyze activity/travel patterns under the activity-based approach, it is important to also collect or derive additional information such as trip purpose, individual/household characteristics, and constraints/interdependencies of scheduling and performing activities. Consequently, it is important to ask questions such as "what GPS data can and cannot tell us?" and "what kinds of information can we derive from the raw GPS tracking data using other technologies such as geographic information systems (GIS)?" In addition, recent developments of information and communications technologies (ICT), such as the Internet and cell phones, have provided an environment that permits people to expand their activities from physical space (e.g., shopping trips) to virtual space (e.g., *e*-shopping). The research community has speculated that ICT could lead to important changes in human activity/travel patterns. It therefore is appropriate to ask how GPS tracking data can assist in studies of changing activity/travel patterns due to ICT.

Time Geography, GPS Tracking Data, and GIS

Hägerstrand's time geography suggests an elegant and simple conceptual framework for studying human activities in a space-time context under different types of constraints (Hägerstrand 1970). Time geography is suggested as one of the origins of activity-based approaches (McNally 2000, Jones 2003). With the dense GPS tracking data, time-geographic

concepts such as space-time path and space-time prism can be examined at finer spatial and temporal resolution levels. In addition, dense GPS tracking data offer potentials to analyze the space-time dynamics of activity/travel patterns. Although time geography offers an elegant conceptual framework, performing measurements and analyses under the time-geographic framework can be challenging (Macnab 2000, Shaw and Yu 2004). For example, how do we analyze interactions among numerous space-time paths derived from GPS tracking data? How can we measure and identify spatiotemporal clusters among the space-time paths? How can we analyze relationships between observed behavior (i.e., space-time paths derived from GPS tracking data) and potential behavior (i.e., available activity opportunities located within space-time prisms)? Geographic information systems have been used to represent the concepts embedded in time geography (e.g., Miller 1991, Kwan 2000). In addition to visualization and query of dense GPS tracking data in a GIS environment, we need a framework to help guide the development of GIS analysis functions for activity modeling (Yu and Shaw 2005). For example, how can we better integrate spatial and temporal components in a GIS environment such that it can facilitate analysis of GPS tracking data to study space-time dynamics? What are the analysis functions needed to examine spatio-temporal interactions between activities of the same individuals as well as the interactions of activities between different individuals?

GPS tracking data no doubt offer good potentials to help us gain better understanding of human activity/travel patterns. Nevertheless, this novel data type requires us think carefully what it can and cannot offer and how we can use the data to carry out useful measurements and analyses for activity modeling (on top of other critical issues such as the protection of privacy).

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