

Chapter 25

Built Environment and Driving Outcomes: The Case for an Integrated GIS/GPS Approach

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ABSTRACT

This study demonstrates a segment-based approach to integrate GIS and GPS data to address questions about the connections between the built environment and travel behaviors. Methods and challenges of GPS/GIS integration are discussed, and an application integrating GPS naturalistic driving data from Southeast Michigan together with GIS data from several sources is demonstrated. The integrated dataset is used to explore connections between the built environment and driving behavior, specifically between business concentration, driving speed, vehicle stops and rear-end crashes. Driving speed, an important determinant of driver behavior linked to traffic safety, is found to be inversely related to business concentration, a pattern that does not vary by time of day. Rear-end crashes are found to increase with vehicle stops which increase with business concentration. This demonstration showed that fusing GPS and GPS data provides spatial intelligence which can be used to address planning, traffic safety, and transportation related issues.

INTRODUCTION

The relationship between travel and the built environment remains a topic of interest and importance in many fields including transportation, urban planning, and public health. The built environment as described by land use patterns and road configurations, is considered to be one of the key determinants of

DOI: 10.4018/978-1-4666-9845-1.ch025

travel behaviors and, by extension, travel safety, energy consumption and pollutant emissions (Banister, Watson & Wood, 1997; Bhat & Guo, 2007; Cervero & Kockelman, 1997; Ewing, Bartholomew, Winkelman, Walters & Chen, 2008; Ewing & Dumbaugh, 2009; Frank, James, Terry, James & et al., 2006; Handy, 1992; Hanson & Schwab, 1986; Maat & Timmermans, 2009). Geographic information systems (GIS) play a key role in advancing our knowledge in the relationships between the built environment and travel outcomes. The increased availability of GIS-based spatial data and advances in GIS tools allow for a more comprehensive development of built environment measures, which could quantify the density, diversity, and design of the built environment (Cervero & Kockelman, 1997; Galster et al., 2001; Krizek, 2003; Song, 2004; Witten, Pearce & Day, 2011). Studies incorporating the newly-developed GIS measures show significant relationships between the built environment and travel outcomes (Cervero & Kockelman, 1997; Frank, et al., 2006).

Along with advancements in GIS measures of the built environment, there has been widespread use of global positioning systems (GPS) for scientific, commercial, navigation, tracking, and surveillance purposes, generating much GPS data on people's travel. This presents opportunities for transportation professionals to monitor and quantify travel behavior in ways that have never been done before. Researchers and practitioners in the transportation field rely on models that are based on data on where, when, and how people travel. Currently, data are collected through traffic volume counts at specific locations and through household travel surveys that rely on respondents completing travel diaries for one or two days. Traffic counts by themselves do not reveal much about travel behavior, and travel surveys are costly, time-consuming, and do not record the specific routes on which people travel. Compared to the traditional trip diary data, GPS data provides highly accurate spatio temporal information including travel routes. Furthermore, GPS technology is capable of tracking human or vehicle movements with a finer level of resolution and during much longer periods, even while imposing fewer burdens on survey respondents (Grengs, Wang & Kostyniuk, 2008; Wolf, 2001; Wolf, Hallmark, Oliveira, Guensler & Sarasua, 1999).

The integration or fusion of GIS-based built environment measures and GPS-based travel records represents a promising new approach to study people's behavior while travelling through the built environment. Map matching, a commonly-used GIS-GPS integration technique, integrates consecutive GPS points organized in time and space with the underlying digitized road maps (Transportation Research Board, 2002; White, Bernstein & Kornhauser, 2000). Such matching allows transportation planners and engineers to explore a variety of spatial interactions between specific road characteristics and travel behaviors. For example, by matching GPS data collected from 45 drivers in the City of Lund, Sweden with road networks, Brundell-Freij and Ericsson (2005) explored the influence of streets environments on driving patterns, and they showed that street characteristics such as traffic light density and speed limit are important variables which influence driving behaviors. Using GPS datasets collected from cyclists in the city of Zurich, Menghini et al. (2010) examined the influence of road characteristics on cycling route choice. Capitalizing on a rich naturalistic driving GPS dataset fused with road networks, researchers studied a variety of travel behaviors related to travel safety, ranging from driving behaviors at intersections, crash surrogates, to lane keeping behaviors along roads (Gordon et al., 2009; Gordon et al., 2011; Nobukawa, Gordon, Barnes & Goodsell, 2011).

Despite the advancements in map matching techniques and its applications in transportation planning and engineering, a comprehensive integration of GPS data with GIS-based built environment measures is still in its infancy. The built environment is a multi-dimensional concept which consists of multiple features such as road network, buildings, businesses, and land uses. With a successful map matching, characteristics of the road networks (such as number of lanes, lane width, speed limit, and traffic lights)

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