Chapter 11
Using Smartphones to Capture Personal Travel Behavior

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ABSTRACT
Embedded with a wide variety of sensors, such as GPSs, accelerometers, gyroscopes, and microphones, smartphones have become a very useful tool in the context of travel surveys. In this chapter, the authors present an innovative tool to estimate individuals’ mobility patterns using an application for smartphones that records GPS and accelerometer data from trips annotated by the user. The authors also present a neural network model for the classification of trips into four transportation modes, based on features extracted from the accelerometer signal. A small sample was collected in Valencia (Spain) to train and evaluate the model. The best classification results were achieved for detecting walking trips (98.2%) and bike rides (99.3%).

INTRODUCTION
Traditionally, travel behavior data have been collected through face-to-face or telephone surveys. People are asked to describe their travel behavior for several consecutive days: travel times, trip origins and destinations, travel modes and other details. However, the burden of collecting such an amount of information negatively affects the quality of the data recorded. For example, short and/or non-motorized trips are often underreported because they are considered too short or too unimportant (Wolf et al., 2001).

The use of smartphones to collect travel data may be a promising means of overcoming these problems. Smartphones offer a broad range of new possibilities for data collection. They provide an interface for questionnaires and enable real-time monitoring of their owners’ behavior. Examples of such behavior include registering daily activities, measuring calories burned, recording personal exposure to noise levels or calculating CO$_2$ footprints. The combination of accelerometer and GPS data is useful to accurately identify start and end points of a trip and transportation modes (e.g., Feng & Timmermans, 2013; Montini et al.,
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To this end, previous studies have shown that Decision Tree-based, Nearest Neighbours and Support Vector Machines are simple and effective algorithms for the classification of transportation modes (e.g., Siirtola & Röning, 2012; Bolbol et al., 2012). Evidence on the predictive ability of Neural Networks is still limited to a few studies despite that initial results have shown high accuracy of neural networks in correctly classifying trips (e.g., Gonzalez et al., 2008; Stenneth et al., 2011).

The present chapter aims at increasing the knowledge about the use of smartphone applications for collecting travel data. In addition, it presents promising results of a neural network trained to recognize four transportation modes: car, metro, walk and bike. This chapter is organized as follows. In the next section, we present the state of the art of this field of research. Section 2 describes the data collection methodology, including the development of the smartphone application. Section 3 explains the data processing, while section 4 shows the results of a neural network to classify transportation modes. Finally, section 5 presents the main conclusions and discusses some avenues of future research.

BACKGROUND

Using smartphones is generally cheaper, faster and more accurate than conventional methods for collecting activity-travel information. Additionally, smartphone-based data collection methods are less of a burden to respondents, compared to paper-based and telephone-based surveys.

GPS Devices

While smartphone-based travel surveys are still gaining prominence, GPS-based surveys have been widely implemented. Travel surveys using GPS devices have gradually become more prevalent worldwide since the first test sponsored by the U.S. Federal Highway Administration in Lexington, Kentucky in 1996 (Wagner, 1997). Examples include the household travel survey conducted in 1997 in Austin, Texas (Pearson, 2001), the California Statewide Household Travel Survey GPS Study (Wolf, 2001) and other projects conducted worldwide: Stopher et al., (2007) in Australia, Schüssler and Axhausen (2008) and Montini et al., (2013) in Switzerland, Bohte and Maat (2009) in the Netherlands, and Rofique et al., (2011) in Great Britain to name a few.

During the last few years, many studies have emerged attempting to infer transportation mode from GPS data. Stopher et al., (2005) implemented procedures to automatically detect the transportation mode used from GPS traces. To detect travel modes, they suggested the use of an elimination method, through which walking segments are first identified, followed by the identification of public transit and private auto. More recently, Moiseeva et al., (2010) developed a system called TraceAnnotator that uses GPS traces, a Web-based prompted recall instrument, and personal spatial information of the respondent to automatically process GPS data to impute transportation modes and activity types. Zheng et al., (2010) used GPS logs collected for 65 people over a period of 10 months and developed an approach based on supervised learning to automatically infer transportation modes from raw GPS records users’, including driving, walking, taking a bus and riding a bike. Similarly, Chen et al., (2010) conducted a passive travel survey in a complex urban environment (New York) using GPS loggers. Their study combined GPS sensor data with GIS information about the underlying transportation network to infer transportation modes. Bolbol et al., (2012) also aimed at solving the problem of inferring transportation modes from GPS data. Users labeled the transportation mode of each segment using an online platform that enabled them to edit their own tracks.

In spite of all the potential advantages using GPS data in travel surveys, signal losses, degradation in high-density cities and cold/warm start issues are common problems of GPS-enabled devices. Accelerometers offer an opportunity