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Workshop synthesis: Conducting travel surveys using portable devices- challenges and research needs

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Abstract

This workshop examined the range of portable devices, their advantages and limitations in terms of technology, the methodologies to extract useful information for travel behavior analysis from portable device data, and how data from multiple sources may be fused together to obtain the data needed for travel demand modeling. In addition, the workshop identified challenges and the research opportunities ahead. But there was general consensus that the travel data collection field is at an exciting point in its history, with unprecedented opportunities to collect rich travel data at fine resolutions of space and time.

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1. Introduction

In recent years, we have witnessed tremendous technology progress in almost every aspect of our lives. Smartphones, GPS navigators, bluetooth devices, tablets, and other wireless devices are becoming ubiquitous. In 2013, 91% of the adults in United States owned a cellular telephone, with 55% of adults indicating they owned a "smartphone" (Smith, 2013). In emerging countries such as Chile, Lebanon, and China, the smartphone ownership is around 40% (Wike and Oates, 2014); in countries such as Australia, Canada, and Ireland, the smartphone ownership

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is at 60% (Mackay, 2012). Smartphones are becoming increasingly prevalent in countries in Africa too, though the ownership rates there have been somewhat difficult to quantify. Nevertheless, WiFi service and infrastructure are increasingly common in public places (such as shopping malls and government facilities) in Africa.

To be sure, people do not merely own these devices—they are using their smartphones and other electronic devices for multiple purposes, such as getting directions, checking on happenings in their neighborhood, connecting and coordinating with their friends and family, and looking for establishments nearby. These devices are small (and getting smaller by the day), easy to carry, GPS-enabled, and easily programmable. This ubiquity of mobile/wireless devices and their potential for automated functioning has unlocked a huge potential for travel data collection. In particular, we are at the point where activity or travel data can be captured automatically and passively, leading to high response rates (Lee-Gosseling et al., 2012, Zmud et al., 2013, Sen and Bricka, 2013, and Rasouli and Timmermans, 2014). However, there are several data collection, handling, and processing challenges that need to be addressed in doing so. These are briefly discussed below.

GPS technology: The success of GPS technology as a survey instrument depends on the ability of the analyst to accurately derive the activity-travel information from the GPS streams (Srinivasan et al., 2009). When GPS-based real-time data is being collected for route choice analysis purposes, there may be line-of-sight obstructions between the GPS device and the satellite caused by tree canopies and tall buildings, and data for certain route segments may not get captured by the GPS device. In other cases, the satellite lock may be frequently lost in downtown areas because of reduced access to the GPS antenna, which may result in a total loss of data for specific routes or segments.

Wireless networking technology protocols, such as bluetooth, can be power intensive, hampering their use. Another challenge lies in the deployment of bluetooth sensor systems for adequate coverage in an urban area (Friesen et al., 2015). After all, bluetooth-based estimation depends on a high penetration of bluetooth technology in a region, as reliability increases with higher penetration. At the same time, the presence of multiple active bluetooth devices in one vehicle could impair origin-destination matrix estimation (Yucel et al., 2013). Lastly, people carrying bluetooth devices are likely to represent a segment of the population that is at the higher end of the income spectrum, thus not providing data on a the entire spectrum of the population (Kostakos, 2008).

Smartphones: One of the key limitations of collecting activity-travel data from smartphones is their battery life. A fully charged smartphone battery will not last longer than 3 hours if the GPS sensor is on. Such a short battery life is undesirable for users and for data collection. Another challenge associated with collecting data through GPS sensors in smartphones is inaccuracy and low frequency of observations. Unlike those used in dedicated GPS devices (such as GPS-equipped vehicles), the sensors embedded in smartphones are low cost and thus more prone to failure. In addition, users often carry smartphones in bags or pockets, which results in a weaker signal. Moreover, data recording intervals are generally set high in smartphones' GPS sensors due to the limitations of the phone's battery life and the cost of transmitting data via wireless networks, which results in sparse observations. Furthermore, GPS data collected from smartphones could be incomplete, as data could be missing (a) when the phone is indoors with no signal connection between the phone's GPS sensor and a satellite, (b) when the phone's battery gets discharged, and (c) at the beginning of trips due to the GPS software's start-up time (Rasouli and Timmermans, 2014). In addition, areas with poor cellphone coverage will adversely affect cell-based data collection efforts. The device may position itself in a location totally different from its actual location, and then find the correct location again, creating nonsensical paths (Stopher and Speisser, 2011). Of course, location inference in smart phones can be upgraded to the level of GPS devices to improve accuracy. While this may have consequences today for battery life and consequent impacts on the completeness of data collection, technology advancements are likely to make this issue mute very soon. More long term though is that the collection of travel data from smartphones invokes concerns about privacy. Protection of the respondents' private data through research and beyond (whether data or other residual information) is of utmost importance, as data collected through smartphones could potentially be used for unintended purposes (Horn et al., 2014). For example, location data could be used to identify a respondent's location and track their movements via the geotags embedded in many digital picture files; further, people who have not given consent for the study could be captured in those photo files (Link et al., 2014). Customized smartphone applications used to