Modeling route choice behavior from smart-phone GPS data

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Abstract
Developing technology has long been harnessed to supplement or replace parts of travel behavior surveys. Tools such as GPS tracking devices have been given to survey participants, to track their movements in a more systematic and unbiased way, instead of relying merely on travel diaries and prompted recall questioning. Tracking survey participants using a specialized GPS device provides numerous challenges: people may forget to charge the device, or leave it at home, and it may not receive a good signal at all times, leaving gaps in the travel record. Data quality from GPS receivers is subject to errors from many sources, including as number of satellites in view, horizontal dilution of position (HDOP), satellite geometry, clock or receiver issues, atmospheric and ionospheric effects, multipath signal reflection and signal blocking (Jun, Guensler et al. 2006; Sch?ssler 2008).

However, in the developed world, and increasingly in the developing world, many people normally carry a wireless phone with them. They already manage the tasks of charging and remembering to carry it, at least as well as they are going to manage those tasks for any special survey device. Therefore, we propose, as in (Stopher 2008), to bundle the survey data collection into a phone. Further, modern "smart phones" often include not only a GPS, but also other instrumentation (and, almost by definition, a wireless antenna for making calls). For instance, the Nokia N95 phone includes the GPS, an accelerometer, a wifi antenna, and a camera, all in addition to the usual phone features. In this paper we will focus on data collection using the N95, and the estimation of state-of-the-art route choice models using that data, in order to illustrate the capabilities of this methodology.

One particular obstacle to using off-the-rack N95 devices for data collection is that the continuous use of GPS receiver in the phone drastically reduces battery charge life, to less than 6 hours in typical conditions. This would obviously be unacceptable in a travel survey setting, where all the afternoon data would be lost--not to mention the annoyance to the survey participant of the loss of the use of the phone in the afternoons for its normal user functions. We will examine strategies for identifying appropriate times to activate and deactivate the battery hungry GPS receiver, using information from the comparatively energy-thrifty GSM and WiFi receivers, and the accelerometer.

Once collected, the rich location and acceleration data from Nokia devices represents a unique opportunity to estimate advanced discrete choice models to predict the travel behavior of individuals. We will examine the efficacy of simultaneously using location information from the GPS receiver, WiFi access points, and GSM tower connections, supplemented by prompted recall questionnaires. These various positioning technologies are not equally reliable or precise: GPS has well known errors, GSM tower usage cannot pinpoint user positions, and WiFi positioning is still new and relatively unproven, and the access points can potentially move around. Combining location points from the three technologies is difficult, because of the differences in accuracy and frequency. In previous studies, location observations with low precision are discarded, and only those location points that are believed to be reasonably accurate are included (Auld, Williams et al. 2008; Stopher 2008). Instead of discarding weak but potentially important data for route choice analysis, we propose retaining this information (both the location and the imprecision) and using a network-free methodology (Bierlaire and Frejinger 2008). This would mitigate potential biases that can be introduced in data post-processing, including those from map-matching.
We will also examine the feasibility of mode detection using accelerometer data. Different modes of transportation exhibit different acceleration patterns: walking involves potentially more bouncing but only slow acceleration, commuter rail travel involves regular acceleration and deceleration at stations, etc. Unfortunately, the accelerometer in a phone is not especially sensitive, and is subject to numerous forces that are not directly related to the owner's travel. This research will examine the relative scales of these conflating forces, and determine if enough useful information can be recovered from the phone accelerometer to aid in the choice modeling process.

References


