An Automated Activity Identification Method for Passively Collected GPS Data

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May 10th, 2010
The 3rd Conference on Innovations in Travel Modeling
Overview

- Introduction
- Problem statement and study scope
- Background
- Methodology
- Case study
- Conclusions and future research
Introduction

- Traditional two-day travel diaries have limitations in representativeness, completeness, and accuracy
  - Household travel variability
  - 25% of trips are missed
  - Various reporting accuracy issues
- Cross-sectional travel data have limited usefulness in disaggregate travel behavior analysis
- Longitudinal travel data are necessary for studying variations in travel behavior over time
- GPS devices that collect travel data passively can be excellent instruments for longitudinal surveys
Limitations of GPS Data

- Limitations of passively collected GPS data include the failure to directly capture:
  - Trip purpose
  - Travel mode
  - Driver identification
  - Number of people involved in the activity
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Problem Statement and Scope

• Develop a methodology to identify trip end activity with passively-collected GPS data
• Use only the household data that would normally be collected during participant recruitment
• Use a commercially-available mapping software that is location independent of the GIS data
• Assume that data cleaning, and processing of the passively collected GPS data has been completed and individual trips have been identified
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Longitudinal travel surveys

- Panels of traditional travel diary surveys
- GPS passive data collection
- Examples
  - Puget Sound Panel Study
  - Commute Atlanta Study
Travel Survey Methods using GPS

- Handheld devices designed to replicate traditional cross-sectional travel diaries
- Longitudinal studies with vehicle-based GPS devices installed in participants’ vehicles
- A hybrid of longitudinal passive GPS data collection coupled with intermittent online travel diary surveys
Identifying Activity type from GPS data

- Wolf, et al., 2001
  - Elimination of the Travel Diary: Experiment to Derive Trip Purpose from Global Positioning System Travel Data
- Schönfelder, et al., 2002
  - Exploring the Potentials of Automatically Collected GPS Data for Travel Behaviour Analysis
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Assumptions

- Assumptions, based upon passively collected data from instrumented vehicles:
  - The radius within which people tend to park their vehicles and walk to a destination is 0.2 miles
  - The points of interest that are closest to the trip end are the most likely locations visited by the individual
  - The search radius for the home location is 500 feet from the trip end
  - The search radius for work and school locations is 1000 feet from the trip end
  - If no points of interest within 0.2 mile of the trip end, the trip purpose is classified as ‘Unknown’
Activity Types

- Home
- Work
- Maintenance (shopping, services, school and dining)
- Discretionary (sports, recreation, social visit, landmarks etc.)
- Multi-purpose (potential)
Coded Points of Interest

- Home
- Work
- School and preschool
- Dining locations
- Shopping and service locations
- Discretionary activity locations
- Locations identified by the household during the recruitment process
Algorithm

Processed GPS Trips with Trip Ends

Less than Home/Work Search Radius

Home/Work

Calculate Distance from Home, and Locations

Search for Businesses/Places of Interest within 0.2 miles

No places within 0.2 miles

Unknown

Find Businesses/Places of Interest that are closest to Trip End

Find Activity Type for those locations

Maintenance/Discretionary

One Activity Type

Multiple Activity Types

Potential Multi-Purpose

Home, and Work Locations from Geocoding and Analysis
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Data

- The University of Minnesota conducted a travel behavior study on the use of the I-35W Bridge
- 46 participants I-35 Bridge commuters
- Participant’s commute vehicle instrumented with GPS device September - December 2008
- GPS device transmitted second-by-second data to the server using GPRS/GSM
- Entire household demographics not collected, only participant’s information
Data Collection Method

- Hybrid travel survey with passive GPS data and interim online travel diaries
- Each participant was asked to complete 6 to 14 days of travel diary during the study
- The participants completed 94% of received travel diary requests
- Participants voluntarily completed extra travel diary days that were not requested
  - Participants reported trip purpose details for twice as many trips as they were asked to provide data
  - 200% reporting rate
Online Survey
Data QA/QC

- Participants completed diaries for 4300 trips
- The initial data set included the 2185 trips for which travel diary were requested
- Some data were eliminated:
  - 150 trips with GPS data issues
  - 250 trips with trip purpose coded as “Other”
  - One household that reported using their vehicle for commercial purposes
  - One household that clearly reported frivolous data
- Retained 1730 trips in the analytical data set
Results

Revealed Purpose

Count

Discretionary  Home  Maintenance  MultiPurpose  Work

Calculated Purpose

Count

Discretionary  Home  Maintenance  Potential MultiPurpose  Unknown  Work
Results
Results

- 67 trips (4%) fall under the ‘Unknown’ category
- 65.4% of the trips were identified correctly
- Home activity predicted with 84% accuracy
- Work activity identified with 71% accuracy
- Maintenance activity identified with 66% accuracy
- Discretionary and potential multi-purpose activities are predicted poorly
Discussion

- It is assumed that stated trip purpose is correct
  - This is not always true
  - One household reported 3 trips starting at 16:04, 16:18 and 16:50 as trips to home
- MapPoint 2006 was used in this analysis and it may not have latest information on points of interest
- Complete household information, such as other work locations, schools, friend’s homes, etc., will further improve prediction accuracy
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Conclusions

- The proposed methodology does not require human interaction to identify the activity type
- With commercial mapping software, the methodology is applicable anywhere in the US
- Eliminates variability in land use data formats used by different organizations
- Assumptions should be re-evaluated with hand-held-GPS data
- The case study found the methodology to be 65% accurate
- Researchers noted that the stated purposes are not always ‘ground truth’
Next Steps

- Incorporate activity duration, time-of-day, and day-of-week into the algorithms being used to identify trip activity
  - e.g., commercial activity occurs during business hours
- Incorporate learning algorithms that will use two-day travel diary data to automatically predict the activities that occur on other days
Cross-tabulation
Revealed Activity vs. Calculated Activity

<table>
<thead>
<tr>
<th>Revealed Purpose</th>
<th>Discretionary</th>
<th>Home</th>
<th>Maintenance</th>
<th>Potential Multi-Purpose</th>
<th>Unknown</th>
<th>Work</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discretionary</td>
<td>13</td>
<td>4</td>
<td>64</td>
<td>11</td>
<td>20</td>
<td>3</td>
<td>115</td>
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<tr>
<td>Home</td>
<td>7</td>
<td>489</td>
<td>69</td>
<td>8</td>
<td>2</td>
<td>8</td>
<td>583</td>
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<tr>
<td>Maintenance</td>
<td>43</td>
<td>41</td>
<td>331</td>
<td>25</td>
<td>26</td>
<td>36</td>
<td>502</td>
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<tr>
<td>Multi-Purpose</td>
<td>9</td>
<td>14</td>
<td>60</td>
<td>4</td>
<td>9</td>
<td>17</td>
<td>113</td>
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<td>63</td>
<td>12</td>
<td>10</td>
<td>295</td>
<td>417</td>
</tr>
<tr>
<td>Total</td>
<td>92</td>
<td>565</td>
<td>587</td>
<td>60</td>
<td>67</td>
<td>359</td>
<td>1730</td>
</tr>
</tbody>
</table>
References

- Elango, V.V., R. Guensler and J. H. Ogle Day-to-Day Travel Variability in the Commute Atlanta, Georgia, Study. Transportation Research Record, 2007.
- Yanzhi Xu and Randall L. Guensler, Advantages of Long-Term Continuous GPS-Based Survey Data For Activity-Based Travel Demand Modeling, Manuscript submitted to the 89th Transportation Research Board Annual Meeting, 2010.
References


