A GPS Data Processing Method For Truck Activity Analysis

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The Importance of Truck Activities to the Region

- Truck activities and regional economic conditions
- Impacts of truck activities
- Data challenges for analyzing truck activities:
  - consistency
  - coverage, and
  - timeliness
Hudson River Crossing Location

• Transportation challenges posed by the Hudson River
  • from the south end of Staten Island to the US/Canadian border

• The complexity of the transportation network in NY/NJ metro region leads to
  • computational burden
  • errors of spatial mismatches
  • assignment confusion
Truck GPS Data Sample Selection Method

Data source: American Transportation Research Institute (ATRI)

• The trucks selected were those appeared in the 28-county NY/NJ Metro region during the sample selection week. The movements of these selected trucks were traced backward/forward for one week.

• Each data entry (or record) is a position read
  • unique truck ID
  • time/date stamp
  • location: latitude, longitude, county, state, country
Challenges of Using GPS Data

- Differentiate between moving and stationary data records
- Irregular and low GPS data reporting frequency
Derive Hudson Crossing Location from GPS Data

Frequency distribution of time intervals between the GPS sighting points before/after crossing the Hudson

<table>
<thead>
<tr>
<th>Time Interval (minute)</th>
<th>2009</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 or less</td>
<td>37.3%</td>
<td>64.6%</td>
<td>94.8%</td>
<td>97.5%</td>
<td>97.5%</td>
</tr>
<tr>
<td>61-75</td>
<td>39.9%</td>
<td>17.6%</td>
<td>0.3%</td>
<td>0.1%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Other</td>
<td>22.8%</td>
<td>17.8%</td>
<td>4.9%</td>
<td>2.4%</td>
<td>2.4%</td>
</tr>
</tbody>
</table>

• Routing choice of river crossing is largely driven by
  • the last stop before the crossing & the first stop after the crossing
  • travel costs
GPS Data Processing Method

• Data structure
  - truck ID
  - current timestamp
  - current location
  - previous timestamp
  - distance travelled from the previous sighting read
  - the time elapsed since the previous sighting read
  - the space mean speed between the current and the previous sighting reads

• Step 1: Motion status detection — determine whether or not the truck is in motion or at stationary at any given time
  - motion/stationary status indicator

• Step 2: Stop identification — differentiate intentional stops from un-intentional stops

• Step 3: Crossing location identification & estimation — determine the crossing locations for a crossing event
Motion Status Detection

• Develop a rule-based algorithm to set the value of motion/stationary status indicator
  * motion/stationary status indicator

• Critical values used for setting the indicator
  * distance travelled between the current and previous sighting points
  * space mean speed between the current and previous sighting points

• The most influential factors in setting the critical values
  * GPS data reporting frequency
  * characteristics of the road network and traffic conditions
  * GPS signal blockage

• Fix false moving status and false short trips
  * calculate the continuous time and the number of reads the truck remained in the same status (either move or stationary)
  * move/stationary_duration
  * move/stationary_counts
Validity Check for Motion Detection Results

- Aggregate analysis for verifying the motion detection results – stationary time vs. time in motion

- Hours of Service Regulations used as a reference point:
  - drive for a maximum of 11 hours, and work for a maximum of 14 hours in a day, before having to take 10 hours off duty or in the sleeper
  - work no more than 70 hours in an 8 day period, before taking a 34-hour reset

- Service cycle length = 8 days * 24 hours/day + 34 hours = 226 hours
- Total number of hours on the move when on duty per service cycle = 70 * (11/14) = 55 hours
- The percentage of time spent on the move per service cycle: 24 ~ 31%

Results:

- Calculate the accumulated time spent on the move and in stationary in the dataset
- The percentage of time spent on the move was 25.5% in 2014
Stop Identification

- Stops
  - intentional stops
  - un-intentional stops

- A stop duration threshold is usually used for differentiating intentional vs. un-intentional stops
  - 10 minutes threshold

2,592 sighting points; 29 business stops out of 146 total stops
The Critical Data Records for a Crossing Event

Point A: the last stop made before the crossing

Point B: the last sighting read before the crossing

Point C: the first sighting read after the crossing

Point D: the first stop made after the crossing

• Four configurations for before/after crossing OD pairs:
  ✦ B to C
  ✦ B to D
  ✦ A to C
  ✦ A to D

Travel direction
Hudson River
Bridge
Hudson Crossing Location Estimation

- Build OD market share lookup table based on the observed crossing events

- OD market share lookup table provided for each before/after crossing OD pair, the percentage of trucks using each available crossing facility
  1. George Washington Bridge, Lincoln Tunnel and Holland Tunnel
  2. Staten Island Bridges
  3. Tappan-Zee
  4. Mid-Hudson bridges
  5. Upper NY area

- Estimate the crossing locations for the un-determined crossing events using the OD market share lookup table
  - Assign a crossing location to each un-determined crossing events

<table>
<thead>
<tr>
<th>Year</th>
<th>Observed</th>
<th>Estimated</th>
<th>Un-determined</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>79.52%</td>
<td>20.30%</td>
<td>0.17%</td>
</tr>
<tr>
<td>2013</td>
<td>81.22%</td>
<td>18.68%</td>
<td>0.10%</td>
</tr>
<tr>
<td>2012</td>
<td>77.55%</td>
<td>21.76%</td>
<td>0.68%</td>
</tr>
<tr>
<td>2011</td>
<td>54.68%</td>
<td>44.99%</td>
<td>0.33%</td>
</tr>
<tr>
<td>2009</td>
<td>36.46%</td>
<td>63.06%</td>
<td>0.48%</td>
</tr>
</tbody>
</table>
An Application of Hudson Crossing Estimation

• Study the changes in truck routing and travel patterns
  • Calculate the share of facility usages by the trucks serving different market segments
    • e.g. long distance market vs. local market
  • Calculate the percentage of trucks using each crossing group by direction (i.e., eastbound and westbound) at different years
  • Analyze the trend of the long-distance, New England bound trucks crossing through New York City

![Graph showing share of long-distance, New England bound trucks crossing through New York City from 2009 to 2014.]
Conclusions and Future Research

- The truck GPS data after being appropriately processed, has the potential to provide much more detailed, consistent and comprehensive information about truck behavior.
- The value of this data source will increase as better quality GPS data collected from more trucks become available at lower cost.
- Cordon/border crossing analysis
- Real Origin/Destination demand that related to core-business activities