The Use and Limitations of Ground Captured GPS Coordinates for Address-Based Samples and In-Person Surveys

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Background

GPS chipsets ubiquitous in mobile devices.
- increasingly inexpensive and accurate

Knowing the location of the device...

Why is this important and how is this useful?
- falsification
- segment error
- location based outcomes
- geofencing

Research Questions

1. Can ground captured coordinates help with data collection quality checks?

2. What can ground captured coordinates tell us about geocoding error of an ABS frame?

Problem: Two Sources of Error (at least)
- GPS Measurement Error (i.e. ground capture error)
- Geocoding Error (address converted to lat/lon)

GPS Measurement Error

All GPS devices have measurement error.

Reported data
- latitude & longitude
- accuracy estimate

Precision vs. Accuracy
GPS Measurement Error

All GPS devices have measurement error.

Reported data
- latitude & longitude
- accuracy estimate

Precision vs. Accuracy

Factors affecting precision & accuracy:
- hardware & software
- satellite number & visibility
- multipath
- atmospheric conditions
- other factors

Device Reported Accuracy
- Contains true location 68% of time
- Assumes normal distribution

Simple test of reported accuracy...

GPS Distance from True Location (ft)

Reported Accuracy 10'
- 68% Confidence
- 95% Confidence

n=1200
GPS coordinates
Interval: 3 sec
Duration: 1 hour
Data Source

- Evaluation of Public Education Campaign on Teen Tobacco (ExPECTT)

Funding:
- Study: Food and Drug Administration Center for Tobacco Products
- Analysis: not funded by FDA

National in-person survey
- Address-Based Sampling Frame (locatable addresses only)
- Multi-stage, area probability sample
- 45,000 address in 446 segments (CBG)
- 225 interviewers

Ground captured coordinates
- 13,824 Addresses in 306 segments (CBG)
- Coordinates captured at first visit
- Samsung Galaxy Tab 2.0 (Model: GT-P3113, 8Gig)

GPS Ground Captured Coordinates

<table>
<thead>
<tr>
<th>Device Reported Accuracy</th>
<th>n</th>
<th>%</th>
<th>Cumulative n</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>10,805</td>
<td>78</td>
<td>10,805</td>
<td>78</td>
</tr>
<tr>
<td>27 – 40</td>
<td>1,421</td>
<td>10</td>
<td>12,226</td>
<td>88</td>
</tr>
<tr>
<td>41 – 52</td>
<td>920</td>
<td>7</td>
<td>13,146</td>
<td>95</td>
</tr>
<tr>
<td>53 – 158</td>
<td>549</td>
<td>4</td>
<td><strong>13,695</strong></td>
<td>99</td>
</tr>
<tr>
<td>159+</td>
<td>129</td>
<td>1</td>
<td>13,824</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>13,824</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Geocoding Results

<table>
<thead>
<tr>
<th>Geocode Level (accuracy)</th>
<th>n</th>
<th>Geocode inside 158°</th>
<th>Median distance (ft)</th>
<th>75th Percentile (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address (high)</td>
<td>12,587</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street (medium)</td>
<td>1,034</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zip Code (low)</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13,695</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What about detecting falsification?

- 43 cases from 5 interviewers were falsified
- 0 would be detected using ground captured GPS

True Curbstoning!

Problem: Only one active ground capture.

<table>
<thead>
<tr>
<th>Geocode Service</th>
<th>Mean (ft)</th>
<th>25th Percentile (ft)</th>
<th>Median distance (ft)</th>
<th>75th Percentile (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TomTom</td>
<td>211</td>
<td>27</td>
<td>47</td>
<td>97</td>
</tr>
<tr>
<td>Arc GIS</td>
<td>234</td>
<td>68</td>
<td>99</td>
<td>144</td>
</tr>
<tr>
<td>TAMU</td>
<td>646</td>
<td>70</td>
<td>110</td>
<td>255</td>
</tr>
</tbody>
</table>

Research Questions

1. Can ground captured coordinates help with data collection quality checks?

   Yes, ground-captured coordinates can help us with identifying potential problems while in the field. More useful for detecting segment error than falsification, though more research is needed for both.

2. What can ground captured coordinates tell us about geocoding error of an ABS frame?

   Comparing TomTom and Arc GIS geocoders, both performed well with TomTom doing better. TAMU should only be used where geocode cannot be found by other sources.
Improvements & Future Research

- Take more than one ground capture
  - active and passive
- Evaluate alternative algorithms
- Investigate other geocode services

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