The Implications of Utilizing Consumer Grade GPS

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Research Questions

- How do consumer grade GPS loggers compare to GIS grade loggers?
- What are sources of error in New York City?
- What should researchers consider when using GPS data?
Overview

- Global Positioning System (GPS) usage in Travel Surveys
- GPS Technology
- Methodology
- Results
- Take Aways for Consideration
GPS usage in Travel Surveys

- Surveys provide demographics, attitudes, opinion & motives
- GPS provides:
  - Spatial and temporal data
    - Acceleration & speed
  - Route path
  - Underreported trips
GPS Technology

- 31 satellites

- Distance = Rate × Time
  - Rate: How fast radio signal is received (speed of light)
  - Time: How long it takes for radio signal to arrive (signal time minus received time)

- At least 4 satellite signals for location estimate
GPS tech cont.

- 7.8 m at 95% confidence
  - Signal distortions
  - Residual receiver delay errors
  - Receiver noise
  - Receiver hardware/software faults
  - Multipath and receiver multipath mitigation
  - User antenna effects
  - Operator (user) error
Consumer Grade GPS

- GPS loggers
- GPS transmitters
- Smartphone applications
  - Wifi & cell phone tower assisted trilateration (AGPS)
- Low cost ($60)
- Chipsets:
  - Qualcomm (including SiRF)
  - U-blox
  - MTK
Methodology

- **GIS grade equipment**
  - Trimble Geo 7X Receiver
  - Zephyr Antenna
  - $10,000

- **Differential Corrections (DGPS)**
  - Base stations
  - Post processing (Trimble Pathfinder)
Methodology cont.

- Measure distance using Vincenty’s formulae
- Matched on timestamp
- 4 different consumer grade devices
- 1 second intervals
## Results

### Basic Statistical Measures

<table>
<thead>
<tr>
<th>Location</th>
<th>Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>16.53090</td>
</tr>
<tr>
<td>Median</td>
<td>10.18832</td>
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<tr>
<td>Mode</td>
<td>5.16950</td>
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<tr>
<td>Std Deviation</td>
<td>19.21971</td>
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<tr>
<td>Variance</td>
<td>369.39707</td>
</tr>
<tr>
<td>Range</td>
<td>196.94931</td>
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<tr>
<td>Interquartile Range</td>
<td>13.17753</td>
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</tbody>
</table>
Errors

- Building height correlated with error
- Multipath error (Canyons)
- Error across all devices
  - Including GIS grade devices
- Block error
Block Error
Quantifying Distance Overestimation From Global Positioning System in Urban Spaces

Stephanie J. Maney, MS; Daniel M. Sheehan, MA; Guzzi Zalewski, MPH; Andrea G. Rundie, DrPH; Kevin McGill, MD; Melika R. Babcock, MD; and Genie Schellhorn Lowen, PhD, MPH

Objectives. To investigate accuracy of distance measures computed from Global Positioning System (GPS) points in New York City.

Methods. We performed structured walks along urban streets carrying Globalstar DG-100 GPS Data Logger devices in highest and lowest quartiles of building height and tree canopy cover. We used ArcGIS version 10.1 to select walks and compute the straight-line distance (Geographic Information System–measured) and sum of distances between consecutive GPS waypoints (GPS-measured) for each walk.

Results. GPS distance overestimates were associated with building height (median overestimate = 9.7% for high vs. 14% for low building height) and to a lesser extent tree canopy (14% for high vs. 25% for low tree canopy).


Global Positioning System (GPS) monitoring of study participants’ physical activity and sedentary behavior has spawned a decade of research in the WorldCom Corp, New Taipei City, Taiwan, devices that had previously been tested and had acquired a signal from at least 1 in 8 GPS records. One device failed to record on 2 walks, which were discarded from analysis.

Next, we explored the effect of tree canopy cover on the basis of data gathered by lidar scan. We planned walks adjacent to cross streets in the highest (n = 10) and lowest quartile (n = 10) of tree canopy cover in New York City. Two research assistants carrying 3 DG-100 devices performed each walk once, resulting in 60 trip records.

We used ArcGIS version 10.1 (ESRI, Redlands, CA) to select walks and to compute the straight-line distance (GIS–measured) and sum of distances between consecutive GPS waypoints (GPS–measured) for each walk. We used R, for Windows version 2.15.3 (T. Foundation for Statistical Computing, Vienna, Austria) for statistical analyses.
Implications

- High resolution geography, higher error rate
  - Rooftop or block geography unstable
- Impacts prompted recall and diary matching
- Error not randomly distributed
- More devices, more variance
- Misclassify mode of travel
Conclusion

- Lat/long is an estimate
- Measures of certainty:
  - Number of satellites
  - Accelerometer
  - Confidence
- Limited hardware solutions
  - Bluetooth beacons
Thank You

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