Leveraging Open-Source GIS Tools to Determine Freight Activity Patterns from Anonymous GPS Data

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Motivations
Understanding Freight Activity

- Goal to enhance modeling tools that guide freight project prioritization and policy development by the public sector.
- Movement of freight supports economic activity (BTS, 2015): $1 out of every $10 produced in the US GDP is related to transportation

Tonnage by Mode (BTS, 2015)

- 10,776 Million Tons
- 3,326 Million Tons
- 1,602 Million Tons
- 884 Million Tons
- 10 Million Tons
Existing Freight Activity Data Sources

Valuable freight data sources are anonymized before release to the public sector to protect privacy, removing necessary context to determine accuracy and usefulness.

- Global Positioning Systems (GPS)
- Crowd-sourced cell phones
- Electronic Logging Devices (ELD)
- Temporary tube counters
- Loop detectors
- Automatic Vehicle Classifiers
- Weigh-In-Motion (WIM)
- National Vehicle Inventory and Use Survey (VIUS)
- Commodity Flow Survey (CFS)
- Regional Intercept Surveys
National Truck GPS Data Sample
American Transportation Research Institute

One Week of ATRI Truck GPS Data Points

Before 1-40 Rockslide

Example of ATRI Study to Examine Route Choice

After 1-40 Rockslide

(Ref: Bernadin et al., 2015)

(Ref: ATRI, 2012)
## Large-Scale Truck GPS Data

### Benefits

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<td>Large streams of GPS data are becoming ubiquitous... connected vehicles</td>
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### Challenges

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<td>Data is anonymous and may not be representative</td>
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<td>Matching GPS positions to the network can be complex given network geometries</td>
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<td>Requires tools not available in packaged GIS products</td>
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Re-creating routes is more difficult than mapping GPS positions to network links.
Arkansas GPS Data Sample

- Over 35 million raw pings per week in Arkansas
- 10-15% coverage of truck traffic
- 2-week sample from August 27th to September 12th, 2016 to better capture agricultural truck movements
  - Total Trucks: 83,112
  - Total Pings: 88,241,136
Arkansas GPS Coverage

(A) Number of trucks per day

(B) Number of daily occurrences
Deriving Freight Activity Patterns

1. Identifying Stops
2. Identifying Routes

Freight Activity by Industry
Deriving Freight Activity Patterns

Stop Identification

Stop Identification Procedure

Data Quality Check

Stop Identification
Data Quality Check

- Calculate total number of pings for a truck
- If total number of pings > 20, calculate the bounding box of all pings
- If the bounding box ≥ 1.2 miles, calculate Space-Mean Speed (SMS)
- If the calculated SMS is ≥ 81 mph, calculate the speed duration
- If the speed duration ≤ 2 minute, mark the truck as a “Qualified Truck” and proceed to Stop-Identification

Modified from Pinjari et al.; Camargo et al.
Example: Bounding Box

Stop cluster for one truck around parking lot

Stop cluster for several trucks around distribution center
Stop Identification

Calculate Space-Mean Speed (SMS) for each ping

Mark ping as “Stop”, if the speed is ≤ 3mph and speed duration ≥ 5 minute within a 0.2 mile bounding box

Identify the nearest business location to each “Stop”

Identify the type of truck from the type of “Stop”

Modified from Pinjari et al.; Camargo et al.
Example: Stop Identification
Open-Source Tools

- QGIS open-source GIS platform
- Python Code
  - Pandas (Data framework)
  - AequilibraE (Path computation)
  - Rtree & Shapely (Geographic operations)
  - Available through GitHub → https://github.com/pedrocamargo/map_matching

2. Camargo et al., “Expanding the Use of Truck GPS Data in Freight Modeling and Planning Activities” (2016)
Characterize Trucks by Stop Locations

- External - External (EE)
- External - Internal (E-I)
- Internal - Internal (I-I)

1st ping, 2nd ping, last ping
Types of Trucks by Stop Locations

Total Trucks: 83,112

Arkansas Trucks: 75,871

- Internal-Internal (II): 3,493
- Internal-External (IE): 10,127
- External-Internal (EI): 6,604
- External-Internal-External (EIE): 53,138
- External-External (EE): 2,509

Out of State Trucks: 7,241

- 70% Internal-Internal (II)
- 13% Internal-External (IE)
- 9% External-Internal (EI)
- 5% External-Internal-External (EIE)
- 3% External-External (EE)
Stops per Truck Type

Average number of stops

- II: 57
- IE: 24
- EI: 14
- EIE: 12
- EE: 0
Connecting Stops to Industry

After adding business layer over truck GPS Pings

After adding Google Satellite Image over truck GPS Pings
Key Take-Aways

- Conventional desktop tools are enough to use the open-source tools to process large streams of GPS data.
- Open-source = better dissemination to public agencies.
- Future study will identify the complete set of consecutive links that comprise a truck's path between stops, e.g. map matching.
- Stop identification and map matching combined paint a clear and distinct picture of freight activity.
Questions?

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