Innovations in Freight Data Workshop

Integrated Freight Survey, Shipment Tracking, and Vehicle Tracking

Presenters:
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Integrated Commodity Flow Survey

Freight data collection methodology
- leverages next generation sensing technologies
- utilizes machine learning in backend
- integrates survey stream using unified, coherent questionnaires

Conduct surveys
- data for policy analysis
- support freight modeling needs

FMS-Freight
Future Mobility Sensing (FMS)
FMS-Freight

1. Registration & Pre-survey
   - Receiver questionnaire
   - Shipper questionnaire
   - Carrier questionnaire
   - Driver pre-survey

2. Tracking
   - Tag shipment
   - Install tracking devices

3. Verification
   - Shipment timeline
   - Driver timeline
System Architecture

MOBILE APP/ TRACKING DEVICES

RAW DATA

MACHINE LEARNING BACKEND

PROCESSED DATA

VERIFIED DATA

MOBILE/WEB INTERFACE

Context Info

- Road network
- Points of Interest
- Land Use
- Events
- Establishment/vehicle/driver Info
- Carrier data
- ...

Timeline

- Activities
- Commodity
- Parking
- Helpers
- Special loads
- Alteration in plan

Sensing Technologies

GPS  GSM
WiFi  Bluetooth
Accelerometer
RFID  OBD

RAW DATA

PROCESSED DATA

VERIFIED DATA
Main Contributions

All electronic, full integration of data between related entities

Machine learning with user verification

Multi-platform, multi-devices
Machine Learning

Main objectives
- Stop detection
- Activity inference

Flexible algorithm to utilize available information
- GPS/OBD/WiFi/accelerometer/barometer etc.
- Contextual information such as frequent places, user history, as well as Points of Interest etc.

Stop detection
- Rule based heuristics
- Random forest
- Change point detection
FMS-Freight Interfaces
FMS-Freight

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## Truck Driver Survey Pilots

<table>
<thead>
<tr>
<th>Time</th>
<th>Sponsor</th>
<th>Recruitment Location</th>
<th>Type</th>
<th>Vehicle Types</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 2014</td>
<td>Ferrovial</td>
<td>US (Texas, Indiana, Ontario, Northeast)</td>
<td>Intercity</td>
<td>Mostly heavy, some single unit</td>
<td>Large (Survey Firm)</td>
</tr>
<tr>
<td>Oct 2016 – Dec 2016</td>
<td>FHWA</td>
<td>US (Boston Metropolitan)</td>
<td>Urban + Intercity</td>
<td>Various, e.g van, single unit, heavy</td>
<td>Small (MIT research team)</td>
</tr>
<tr>
<td>Feb 2017 – Present</td>
<td>URA</td>
<td>Singapore</td>
<td>Urban</td>
<td>Heavy</td>
<td>Large (Survey Firm)</td>
</tr>
</tbody>
</table>
Assisted machine learning enhancing GPS

- Tour patterns
  1. Intercity
     i. Long tour
     ii. Short tour
     iii. Gypsy
  2. Urban
     i. Chained tours
     ii. Centralized tours
     iii. Decentralized tours
  3. Mixed

- Stop sequence (and route) in one tour
  1. Distance based stop sequence
  2. Cargo based stop sequence
  3. Location/timing based stop sequence

- Activity patterns for one day
1. Intercity: Long tour

Time Space Diagram
User 59

Day

Distance from Home Location (km)

- Load
- Toll
- Unload
- Other
- Rest
1. Intercity: Short tour

Time Space Diagram
User 66

- Load
- Toll
- Unload
- Other
- Rest

Distance from Home Location (km)
1. Intercity: ‘Gypsy’

Time Space Diagram
User 141

Distance from Home Location (km)

Day

Load
Toll
Unload
Other
Rest
2. Urban: chained tours
2. Urban: centralized tours, time of day route choice
2. Urban: decentralized tours
distance based stop sequence choice
3. Mixed: Intercity and Urban

Time Space Diagram
Mixed Driver (41)

- Load
- Unload
- Rest
- Other
- Pick up Trailer
- Drop off Trailer
3. Mixed: Intercity and Urban Variability for One Driver

- Snow day: deliver snow plows on snow days
- Typical non-snow day: deliver machine parts with a different tour pattern
Stop Sequence Patterns: cargo based stop sequence choice

- Shipping carrier, express cargo at stop 6
- User 61 took detour to deliver 6 first then go back to deliver 7
Stop Sequence Patterns: location/timing based stop sequence choice

- Pickup in Boston, deliver to Long Island and New York City
- Deliver in Long Island first by taking the ferry to avoid morning peak in New York City
- Cost of ferry v.s. value of time
Urban Activity Patterns: Monday

HVP Batch 1 Activity on Monday

% of Truck Drivers

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Time of the Day

00:00 02:00 04:00 06:00 08:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 24:00

ChangeShift
Delivery/Pickup
Work(Other)
Meal/DayRest
Activity(Other)
Travel
Urban Activity Patterns: Sunday

HVP Batch 1 Activity on Sunday

% of Truck Drivers

Time of the Day

0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 24:00

Legend:
- ChangeShift
- Delivery/Pickup
- Work(Other)
- Meal/DayRest
- Activity(Other)
- Travel
Conclusions and Next Steps

Conclusion
• Integrated freight survey platform
• GPS combined with assisted machine learning to enable rich and high resolution data
• Previously unavailable insights into freight movement
• Behavior modeling innovations, e.g. stop sequence choice, route choice, activity pattern clusters

Next Steps
• Singapore Pilots
  – Integrated freight survey in Changi (started Nov 2016)
• US Pilots
  – Shipment survey (2017)
  – Larger integrated vehicle and shipment survey (2018)
Thank you!
Questions and comments?

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Pilot Survey Websites:
https://truckers.mit.edu
freight-sg.fmsensing.com
Appendix
Paris Urban Freight Survey

Three combined surveys for complementary results

Establishment survey

Driver survey

Haulier survey

General information
- Phone contact
  - First visit
  - Second visit

Log book (1 week)
- Description of pick-ups and deliveries
- Pick-ups/deliveries
- Goods

Driver questionnaire
- Route
  - Stops
  - Trip sections

Mathieu Gardrat @ LET
Truck Driver Survey in US 2014

- Intercity, mostly heavy with some single unit, recruited in Texas, Indiana, Ontario (Canada), Northeast US
- Survey firm recruitment and verification
- Compensate $100, logger tracking, daily verification online (by driver) or via phone (by surveyor)
- Recruited 107 drivers, 2255 days pilot
Truck Driver Survey in US 2016

- Intercity and urban, a variety of freight vehicle types, recruited in Boston Metropolitan
- MIT research team recruitment and verification
- Compensate $100, logger tracking, daily verification for 15 days online (by driver) or via phone (by surveyor)
- 28 recruited drivers (8 urban, 15 intercity, 5 mixed), 18 completed, 53 days pilot, 650 days tracking, 442 days verified
  - Intercity: carries freight beyond a local or metropolitan area
  - Urban: collects and delivers freight within the limits of a local or metropolitan area
  - Mixed: some days urban, some days intercity; deliver in multiple urban areas daily
Truck Driver Survey in Singapore 2017

• Urban freight, heavy vehicles, recruited in Tampines heavy vehicle parks (east island)
• Logger installation by Quantum Inventions in batches (mandatory), recruitment for survey by Agility (optional)
• Vouchers as reward, daily verification for a week, online (by driver) or via phone (by surveyor)
• 629 drivers tracked, 282 recruited for survey, 206 verified 5 week days and some weekends
Route Patterns: cargo/vehicle based choice

- Circuitous route (red line) from stop 1 to stop 2
- Auto carrier, oversize cargo, GPS as navigation source
- Cannot make tight turns or enter narrow roads suggested by GPS (blue line)
2. Urban: chained tours
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