Oct 2011

Visualizing Bus Schedule Adherence and Passenger Load through Marey Graphs

ITS World Congress
Constructing Marey Graphs

Schedule data

+ APC data

+ Shading

+ Pax loading
Depicting Passenger Load
For ICM:
Bay Tripper
Current Technology Research

Raja Sengupta

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Bay Tripper Research
ICM Task: Port from Iphone to Android
Bay Tripper Claim to Fame

- Cool client design – Eric Mai
- Real-time Transit Routing – Jerry Jariyasunant
- Based on NextBus relationship (Jerry)
BayTripper: Client Side Features and Usage

September 28, 2011
Thanks for checking out BayTripper!

We are a couple students from UC Berkeley who created this app to help users in San Francisco get around by finding their way through transit and bike routes. This is part of a research project trying to understand how to get more people to get out of their cars and onto bikes, public transportation, or just walk!

Download BayTripper now for FREE!

Our app lets you...

- Get real-time arrivals for MUNI and BART
- Plan a trip with our Real-time Transit Trip Planner
- Plan a bike trip with your own personal preferences for safety and hill tolerance (powered by www.bikesy.com)
- Look up schedules for Caltrain, BART, and Bay Area Ferries (Blue and Gold Fleet, Golden Gate Ferry, Alameda Harbor Bay Ferry) to Sausalito, Larkspur, Alameda, Oakland, Vallejo, and more
- Look up local transit maps from Muni, BART and Caltrain
- Call a taxi from a list of popular cab companies in San Francisco

The transit trip planner uses real-time data provided by NextBus, which takes into consideration the actual location of buses, delays and tries to help users avoid missed transfers. At this time, users can only plan trips within San Francisco (including Treasure Island).

Follow us on Twitter for updates on BayTripper!
Usage Statistics

Active Users represent 11.3% of total downloads.

"Users stop using the average applications quickly. Long term audiences are generally 1% of total downloads" - Pinch Media


1,142 active users and 5,126 total sessions the week of August 22.

BayTripper has not been publicized. Steady usage increases have come through word of mouth.

UCB Mode Choice Research Group

(systems.berkeley.edu/jerry/ModeChoiceWebsite)
Usage Statistics
BayTripper Features
BayTripper

Description
BayTripper is an easy and fun way to get around the whole Bay Area on bike and also tap into real-time routing information for San Francisco, California on BART and MUNI.

What's New in Version 2.43
Fixed the favorites problem: you can favorite SF Muni stops again.

UCB Mode Choice Research Group
(systems.berkeley.edu/jerry/ModeChoiceWebsite)
BayTripper Demo
BayTripper Reviews

“Thanks for the fix with that MUNI bug! Awesome app, I use this everyday and sometimes to plan long bike rides on the go.” - shuffleman

“Hey this app is the beat sf app hands down! It’s got everything you need and a map!” - klok99ah

“Loveeeeee it. Just let me rearrange my faves. A+” - Pont0005
Bay Tripper: Server Side

- Real-time Transit Routing – Jerry Jariyasunant
- Based on NextBus relationship (Jerry)
Real-time Routing: Challenges

- High dimension Routing Problem

- Bus data provider web API limits data per request

- Cannot ask for database dump


Solution: Querying NextBus per customer query
Complexity of real-time transit routing 1

770,000 O-D’s
Technical Approach: Real-time routing for transit

- Map user O-D to set of networks OD’s
  - Line sources and sinks

- For each network OD pre-compile a list of routes
  - Based on GTFS specification and schedule (off-line)
    - Hundreds to thousands of routes for each O-D
    - Real-time Query NextBus for data for each list
      - Reduces hundreds of routes to 10’s of stops

- Pick the minimum off each list and return to client

Complexity of real-time transit routing 2

Real-Time API hits in Washington D.C. for different walking distance ranges
Server Tools

• Behind the scenes of BayTripper: Routing Algorithms
• Custom Tools to import any transit agency (GTFS) into our system and run a real-time transit trip planner (If they use NextBus). Currently hold data on 77 agencies nationwide.
• Use Graphserver, an open-source multi-modal trip planner to do custom biking directions for personalized hill tolerance and safety level
• Recently ran 10,000 simulations per agency to test robustness
• Walking/Driving directions next
Bay Area AC Transit with 73 routes
Los Angeles MTA pilot with 192 Routes
Current Technology
Development Research
Behavior Change Technology

- Past: Safer Driving
- Networked Traveler – Slow Traffic Ahead
- Changing Mode Choice Behavior
- UCTC, Caltrans
- Shopping Behavior
- CITRIS Seed
Mode Choice Behavior

- The basic idea
- Technologies
The Quantified Traveler

Visualizing GPS Data but for the traveler

Raja Sengupta

CEE: Systems, UC Berkeley
Nudging Behavior
Quantified Self

• Applications that
  – Record behavior
  – Process data
  – Feed it back

• Goals
  – Better understand patterns
  – Adapt behavior more intelligently

• Examples
  – Fitness
  – Mood
  – Sleep
  – Spending habits
Our Quantified Traveler System
Quantified Traveler

Smartphone tracking

Trip determination

Website feedback

Social Comparisons
How You Get Around

By Number of Trips:
- Drive: 65.9%
- Walk: 14.6%
- Bike: 9.8%
- Bus: 7.3%
- Train: 1.6%

By Time (min):
- Drive: 58.8%
- Walk: 19.9%
- Bike: 10.9%
- Bus: 6%
- Train: 8.6%

By Distance (mi):
- Drive: 49.6%
- Walk: 13.5%
- Bike: 8.6%
- Bus: 6%
- Train: 9%
Quantified Traveler: Social Comparisons

Total Trips Logged: 82
Total Miles Logged: 347
Total Time Logged: 1736 minutes

Average Travel Statistics:
- Bay Area
- National
- Study Group
- You

Diagram showing comparisons of time, emissions, calories, and cost.
July Field Test: Procedure

- Participant group: 28 young professionals

- Duration: 2 weeks of self-tracking
  - First 5 days: No feedback.
  - 5th day: Users receive feedback website link
    information on environmental, health, financial and time footprint of travel behavior.
  - Day 6 to 14: Regular updates by e-mail.

- Survey administered before and after experiment
  Questions on:
  - awareness of impacts of transportation behavior
  - attitudes toward sustainable travel behavior
Travel Patterns of 25 Subjects

Figure 3: Mode split by number of trips made (Drive: 30.34%, Walk: 43.65%, Bike: 13.50%, Bus: 4.63%, Train: 7.49%, Light Rail: 0.39%)

Figure 4: By total travel time (Drive: 45.11%, Walk: 24.63%, Bike: 10.49%, Bus: 11.39%, Train: 8.12%, Light Rail: 0.25%)
# Sample Survey Questions

<table>
<thead>
<tr>
<th>Category</th>
<th>Sample Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness</td>
<td>I know how much $CO_2$ I emit from my daily transportation.</td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>I can get exercise when traveling.</td>
</tr>
<tr>
<td>Perceived Norms</td>
<td>My friends actually engage in sustainable transportation behavior (carpooling/biking/walking/taking public transit)</td>
</tr>
<tr>
<td>Setting Goals</td>
<td>I would consider setting a goal to reduce my carbon footprint.</td>
</tr>
<tr>
<td>Attitudes on Sustainable Behavior</td>
<td>I value the benefits to society when I take sustainable modes of transportation.</td>
</tr>
</tbody>
</table>

Table 2: Sample questions given to participants at the beginning and end of the study
## Survey Results

<table>
<thead>
<tr>
<th></th>
<th>Mean (before)</th>
<th>Mean (after)</th>
<th>Standard Deviation (before)</th>
<th>Standard Deviation (after)</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness</td>
<td>2.91</td>
<td>3.75</td>
<td>0.22</td>
<td>0.27</td>
<td>2.8210</td>
<td>0.0106</td>
</tr>
<tr>
<td>Perceived norms</td>
<td>5.64</td>
<td>5.60</td>
<td>1.17</td>
<td>0.98</td>
<td>0.2483</td>
<td>0.8065</td>
</tr>
<tr>
<td>Setting goals</td>
<td>4.14</td>
<td>4.36</td>
<td>0.90</td>
<td>1.05</td>
<td>1.0141</td>
<td>0.2060</td>
</tr>
<tr>
<td>Attitudes toward</td>
<td>5.12</td>
<td>5.38</td>
<td>1.18</td>
<td>0.95</td>
<td>2.2326</td>
<td>0.0372</td>
</tr>
<tr>
<td></td>
<td>sustain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sustainable</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>behavior</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 3: Comparison of participants’ survey answers before and after tracking and feedback
Results

- 1016 trips logged during the 2 weeks (approx. 2.9 per day and person)
- All users visited website at least once; good user feedback on website

- Survey results:
  - All awareness questions (environment, health, money, time) showed positive change; environmental awareness was strongest.
    - E.g., “I know how much CO2 I emit from transportation”
  - Statistically significant positive changes attitudinal questions on sustainable transportation
    - E.g., “We should raise the price of gasoline to reduce congestion and air pollution
  - Positive correlation between car use and attitudes toward sustainable travel
Evaluations to Date

- 45,000+ miles of travel collected
- 10 Students in DeCal class
- 25 Subjects in July Experiment
- 25 BetaTesters recruited by MileSense
Quantified Traveler: Under the hood

- **July Field Test System**
  - 1 Hz GPS data
    - 25% battery drain per hour (Nexus One)
    - Iphone - 7% (moving, 3% not moving)
  - Not deployable at scale
  - Mode Determination Excellent

- Can we bring energy consumption down to make it deployable at scale **while maintaining accuracy of trip determination, mode determination, GHG estimates, ....**
  - October design now being evaluated
The Mode Determination Problem

- **Instant mode determination**: identify the transportation mode used at each time instant (as walking, biking, driving etc.)
- **Trip mode determination**: identify the main transportation mode used (as walk, bike, shared ride, walk-transit etc.)

Computer science community’s definition

Transportation community needs

Can we link?
Eighteen modes defined for the Bay Area*

- Activity-based travel model specifications: Coordinated travel - regional activity based modeling platform (ct-ramp) for the San Francisco Bay Area
Identifying the Trip Mode (HMM)

(a) Walk trip model

(b) Bike trip model

(c) Motorized trip model

Map-matching
July 2011: Playing with Sampling Rates

- GPS Sampling Rate = 1/10 Hz
- Accelerometer Sampling Rate = 5 Hz
- GPS Sampling Rate = 1/60 Hz
- Accelerometer Sampling Rate = 1 Hz
Results – detecting trips

(a) Confusion Matrix before Map Matching (%)

<table>
<thead>
<tr>
<th>Actual</th>
<th>Auto-trip</th>
<th>Transit-trip</th>
<th>Bike-trip</th>
<th>Walk-trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive-trip</td>
<td>77.0</td>
<td>20.2</td>
<td>0.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Transit-trip</td>
<td>44.0</td>
<td>56.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bike-trip</td>
<td>0</td>
<td>0</td>
<td>97.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Walk-trip</td>
<td>0</td>
<td>3.9</td>
<td>3.0</td>
<td>93.1</td>
</tr>
</tbody>
</table>

(b) Confusion Matrix after Map Matching (%)

<table>
<thead>
<tr>
<th>Actual</th>
<th>Auto-trip</th>
<th>Transit-trip</th>
<th>Bike-trip</th>
<th>Walk-trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-trip</td>
<td>85.9</td>
<td>11.3</td>
<td>0.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Transit-trip</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bike-trip</td>
<td>0</td>
<td>0</td>
<td>97.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Walk-trip</td>
<td>3.9</td>
<td>0</td>
<td>3.0</td>
<td>93.1</td>
</tr>
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</table>

Accl 5 Hz, GPS 1 min
Current Solutions: Energy

Trip Explorer

Analytics

GPS/Acc/Skyhook/Tower → O, D, Trip, Mode
Battery Depletion – Quick and Dirty Calculations

- Looking at 44298 50-second increments (4908 of which were in transit modes) one can ascertain delation rates in an unsophisticated but reassuring manner.
- All data has been filtered of screen, phone call, SMS usage and charging periods.

<table>
<thead>
<tr>
<th></th>
<th>Observed (per hour)</th>
<th>Estimated depletion per hour</th>
<th>Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Transit Modes</td>
<td>-2.37%</td>
<td>-0.45%</td>
<td>0.04%</td>
</tr>
<tr>
<td>Transit Modes</td>
<td>-5.48%</td>
<td>-4.57%</td>
<td>0.27%</td>
</tr>
</tbody>
</table>

- ~25% per day if one's commute is 2 hours.
The Price of Battery Efficiency: Sparsity of data
The Price of Battery Efficiency: Hotspots
July Solution: Mode Determination

• Combination of accelerometer features and GPS speed
  – Examples of accelerometer features:
  – Sum of features centered around 1 Hz
  – Normalized variance
  – Spectrum peak value and frequency
  – 1,2,3 hz power

• Map Matching
  – Source Data: GTFS (Google Transit Feed Specification)
  – Buses: look at stop sequences (and locations of bus stops)
  – Trains: look at shape files for track locations
Trip & Mode Determination: Accuracy

• How many people in Quantified Traveler
  – 6 people

• How much time being spent on correction?
  – Mike and John 1 minute a day/person
  – Stasa and Adam 10 minutes a day/person
    • No accelerometer in background
    • No routes for the Google Shuttle
    • BART underground system problem
  – Jerry 20 seconds per person per day (drivers)
    • 4 months, 25 people
Collaborators

- Adam Bemo
- Andre Carrel
- Venky Ekambaram
- DJ Gaker
- John Gunnison
- Jerry Jariyasunant
- Mike Nole
- Siddika Partak
- Daniel Vizzini

- Professor Joan Walker
Energy Consumption VS Trip, Mode Accuracy
Motivation

• NetDiary instead of Travel Diary
  – Can smartPhones improve travel demand surveys?

• Education and Awareness
  – How sustainable am I? What are my alternatives?

• Persuasion
  – Change mode-choice for sustainable travel
  – Travel feedback programs
  – People persuade people. Can computational systems persuade people?