דוגמאות ליישומי ניטוח רשתות ברחמת התחבורה
(הציבורית)

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Ramat Gan, Israel

כנס "יישומי נתונים סביבתיים של מדעי הנתונים" 23/10/18, בר-אילן.
Outline

• PT 101
• Open data for PT (GTFS)
• PT Spatiotemporal analysis


PT 101
45 people on the move individually (left) and together (right). One basic idea of public transport is to induce people to travel together in vehicle units that are more space efficient than the motorcar. The intrinsic need for transfers in public transport networks follows from this basic idea of many people travelling together in bigger vehicle units rather than individually and directly door-to-door. PHOTO: SVEN MAGNE FREDRIKSEN
PT systems characteristics

- **Time**
  - Time
  - Ride
  - Wait
  - Board/Alight
  - Walk

- **Space**
  - Distance
  - Comfort
  - Effort

- **Level of service**
  - Accessibility
  - Frequency
  - Capacity
  - Reliability

- **Information**
  - Direction
  - Location
  - Arrival time

- **Priority at intersections, dedicated lanes**
- **Timetables synchronization, operational tactics**
- **Electronic payments**

- **Stations location, connection, ease of connection**

- **Network design, optimization**

- **Navigation systems, automatic data collection, low-energy positioning, micro navigation**

The Transit Capacity and Quality of Service Manual, (Kittelson and Associates et al., 2003)
Public Transit Design & Operations

• Design (predetermined goals – static data):
  • Network design (routes)
  • Setting frequencies
  • Timetable development
  • Vehicle scheduling
  • Crew scheduling

• Operations (real-time data & reliability – dynamic data):
  • Priority
  • Tactics
Open Data (GTFS)
What Is Google Transit?

Google Transit

Plan a trip using public transportation

Use Google Maps to

- Get step-by-step transit directions
  - on your mobile phone
- Find transit stops in your area
- View station information and schedules

Join the transit partner program

Get transit directions

Start address

Destination address

Leave: 7/15/12 4:54pm

Get directions

See what cities are covered (more than 485)

Recent highlights: United Kingdom, London, Sweden, Athens

View text only version
Transit Directions

Transit directions to University of Auckland

Suggested routes
1. 19 mins
   11:47am - 12:06pm
2. 16 mins
   11:54am - 12:10pm
3. 19 mins
   11:57am - 12:16pm

156 Vincent St
Auckland Central 1010, New Zealand
- Walk to 145 Karangahape Rd
  About 7 mins (600 m)
- 145 Karangahape Rd Stop ID: 7131
  Bus towards Victoria Prk
  11:55am - 12:05pm (10 mins, 5 stops)
- Opposite 8 Grofion Rd Stop ID: 1631
  Walk to 22 Princes Street, Auckland 1010, New Zealand
  About 1 min (71 m)

University of Auckland
22 Princes Street
Auckland 1010, New Zealand
What is GTFS?

• The General Transit Feed Specification (GTFS) defines a common format for public transportation schedules and associated geographic information. GTFS "feeds" allow public transit agencies to publish their transit data and developers to write applications that consume that data in an interoperable way (Google Developers, 2012)

• Enables authorities and operators to easily publish static data

• Enables developers to supply information to users (with real-time information)

• Enables researchers to easily investigate real world data
## The General Transit Feed Specification Data Tables

<table>
<thead>
<tr>
<th>Data Table</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agency</td>
<td>This file contains information about one or more transit agencies that provide the data in this feed.</td>
</tr>
<tr>
<td>Stops</td>
<td>This file contains information about individual locations where vehicles pick up or drop off passengers.</td>
</tr>
<tr>
<td>Routes</td>
<td>This file contains information about a transit organization's routes. A route is a group of trips that are displayed to riders as a single service.</td>
</tr>
<tr>
<td>Trips</td>
<td>This file lists all trips and their routes. A trip is a sequence of two or more stops that occurs at specific time.</td>
</tr>
<tr>
<td>Stop times</td>
<td>This file lists the times that a vehicle arrives at and departs from individual stops for each trip.</td>
</tr>
<tr>
<td>Calendar</td>
<td>This file defines dates for service IDs using a weekly schedule. Specify when service starts and ends, as well as days of the week where service is available.</td>
</tr>
<tr>
<td>Calendar dates</td>
<td>This file lists exceptions for the service IDs defined in the calendar.txt file. If calendar_dates.txt includes ALL dates of service, this file may be specified instead of calendar.txt.</td>
</tr>
<tr>
<td>Fare rules</td>
<td>This file defines the rules for applying fare information for a transit organization's routes.</td>
</tr>
<tr>
<td>Shapes</td>
<td>This file defines the rules for drawing lines on a map to represent a transit organization's routes.</td>
</tr>
<tr>
<td>Frequencies</td>
<td>This file defines the headway (time between trips) for routes with variable frequency of service.</td>
</tr>
<tr>
<td>Transfers</td>
<td>This file defines the rules for making connections at transfer points between routes.</td>
</tr>
</tbody>
</table>
Agencies providing GTFS feeds

<table>
<thead>
<tr>
<th></th>
<th>7/12</th>
<th>11/13</th>
<th>12/16</th>
<th>10/18*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open access</td>
<td>245</td>
<td>290</td>
<td>292</td>
<td>323</td>
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<tr>
<td>No access</td>
<td>677</td>
<td>736</td>
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<tr>
<td>Total</td>
<td>922</td>
<td>1026</td>
<td>1026</td>
<td></td>
</tr>
</tbody>
</table>

(http://www.citygoround.org)
* - Google feeds
GTFS based assessment of PT systems
Objectives (1)

• Develop a model for assessing PT connectivity based on the attributes of time and transfer by mode
• Provide a decision-support tool for the identification of inefficiencies in the public-transit system
Trip Components
Connecting stops
Creating routes
PT routes
Road network and PT routes
Trip’s Dimensions

- Street-crossing transfer
- Sidewalk transfer
- Non-walk transfer
- One-leg trip

Ride time ($\alpha=1$)
Wait time ($\alpha=3$)
Walk time ($\alpha=2$)

Time

Transfer
Street-crossing transfer
Sidewalk transfer
Non-walk transfer
One-leg trip
Case study
Case Study (Auckland, New Zealand)
# Results

## Average Travel Time Analysis

<table>
<thead>
<tr>
<th>Origin Destination</th>
<th>OD Pairs Paths</th>
<th>Travel Time</th>
<th>Ride Time</th>
<th>Wait Time</th>
<th>Walk Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auckland Auckland</td>
<td>108,368</td>
<td>34.79</td>
<td>15.59</td>
<td>10.83</td>
<td>8.37</td>
</tr>
<tr>
<td>Auckland North Shore</td>
<td>38,396</td>
<td>74.74</td>
<td>40.54</td>
<td>24.54</td>
<td>9.66</td>
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<tr>
<td>North Shore Auckland</td>
<td>38,396</td>
<td>55.76</td>
<td>32.39</td>
<td>16.88</td>
<td>6.49</td>
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<tr>
<td>North Shore North Shore</td>
<td>13,254</td>
<td>39.79</td>
<td>14.55</td>
<td>17.83</td>
<td>7.41</td>
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</table>

## Trips Legs and Mode Split Analysis

<table>
<thead>
<tr>
<th>Origin Destination</th>
<th>Average Trip Legs</th>
<th>% Bus</th>
<th>% Rail</th>
<th>% Ferry</th>
<th>% Walk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auckland Auckland</td>
<td>1.17</td>
<td>46%</td>
<td>2%</td>
<td>0%</td>
<td>52%</td>
</tr>
<tr>
<td>Auckland North Shore</td>
<td>2.36</td>
<td>49%</td>
<td>2%</td>
<td>2%</td>
<td>47%</td>
</tr>
<tr>
<td>North Shore Auckland</td>
<td>1.76</td>
<td>55%</td>
<td>0%</td>
<td>2%</td>
<td>44%</td>
</tr>
<tr>
<td>North Shore North Shore</td>
<td>1.31</td>
<td>53%</td>
<td>0%</td>
<td>0%</td>
<td>47%</td>
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</tbody>
</table>

## Transfer-Type Analysis

<table>
<thead>
<tr>
<th>Origin Destination</th>
<th>% Transfers</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Street Crossing</td>
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<tr>
<td>Auckland Auckland</td>
<td>73%</td>
</tr>
<tr>
<td>Auckland North Shore</td>
<td>77%</td>
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<tr>
<td>North Shore Auckland</td>
<td>76%</td>
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<tr>
<td>North Shore North Shore</td>
<td>57%</td>
</tr>
</tbody>
</table>
Objectives (2)

- The assessment is based solely on Google-transit data and transport networks

PT data, Network, Demand
Speed Analysis

Auckland

Portland

Vancouver
Road coverage in Auckland CBD

08PM-10PM

08AM-10AM
Road coverage in Vancouver
Stop-transfer Potential

<table>
<thead>
<tr>
<th>wait</th>
<th>Dist.</th>
<th>50m</th>
<th>100m</th>
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</thead>
<tbody>
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<td>1min</td>
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<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5min</td>
<td></td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>
Stop-transfer potential maps

Auckland

Portland

Vancouver
Good planning - space and time
Objectives (3)

• The assessment is based solely on Google-transit data and demand
Destination-direct stop coverage indicator

Destination set 1

Destination set 2
School accessibility
Objectives (4)

• The assessment is based solely on Google-transit data
The question

• Is the new timetable better?
Public transportation in Jerusalem continues to make progress towards providing faster, more efficient and better service.

Dear passengers,

On 21.2.14 the routes of several lines operating in Jerusalem will be changed as part of the continuous improvement of the city's public transportation system.

Great emphasis was put on improving the service and accessibility to the city's central employment areas: Talpiot, Givat Shaul, the Technological Garden, Malcha and the Government Complex. From now on there will be more lines that will lead you more frequently and comfortably to and from work.

The planning of the new lines is a result of cooperation between the Ministry of Transport, the Jerusalem Municipality and public representatives, through the Jerusalem Transport Master Plan team (JTM). This pamphlet provides, for your convenience, all the information concerning the lines included in this phase: before you is a layout of the new and improved lines, station locations and line changes on the way to your destination.

We wish to thank the public representatives who assisted in the planning of the new routes, and to you, the passengers, for your patience and cooperation during the implementation of this change. We are always at your service.
Cancelled lines

<table>
<thead>
<tr>
<th>Line</th>
<th>Status</th>
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<tbody>
<tr>
<td>6A</td>
<td>Cancelled</td>
</tr>
<tr>
<td>8A</td>
<td>Cancelled</td>
</tr>
<tr>
<td>38A</td>
<td>Cancelled</td>
</tr>
<tr>
<td>45A</td>
<td>Cancelled</td>
</tr>
<tr>
<td>47A</td>
<td>Cancelled</td>
</tr>
<tr>
<td>63A</td>
<td>Cancelled</td>
</tr>
</tbody>
</table>

See alternatives on pages 5-7

Changes in Line Numbers

<table>
<thead>
<tr>
<th>Line</th>
<th>Original</th>
<th>New Line</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>77,77A</td>
<td>77,77A</td>
</tr>
<tr>
<td>13A</td>
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<tr>
<td>16A</td>
<td>716</td>
<td>716</td>
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<td>34-34A</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>36A</td>
<td>136</td>
<td>136</td>
</tr>
<tr>
<td>46-46A</td>
<td>53</td>
<td>53</td>
</tr>
</tbody>
</table>

The French Hill - City center - Malcha Mall
4A to Mt. Scopus has been cancelled. See updated route on page 26

Great Menashe - Mt. Herzel
Unchanged route

Ramat - Ramat
Unchanged route

Chomut Shmuel - Gilo terminal
Updated route on page 28

Nabi Samuel - Zachs square
Unchanged route

Neve Yaakov Terminal - Mt. Scopus
Unchanged route

Has the line changed?
There is an alternative!

At Psgat Zeév

Instead of the old line 6 and line 6A, which has been cancelled you can take the new lines 66, 66A, to the city center, Central Bus Station and Givat Ram.

From the Central Station to Malcha Mall you can take one of the following lines 6 to 716.

Instead of old line 8 you can take new line 65 to Eschel Blvd, Bar-Ilani St., Yirmiyahu St. and Gesher HaMeltzanim (Chords Bridge).

To the city center you can change to the Light Rail.

Instead of line 6A which has been cancelled you can take the new line 65 to the Givat Shaul Industrial Zone. Pay attention! The route does not pass through the city center.

Neve Yaakov

Instead of line 45 which has been cancelled you can take line 45 without changing routes

Pay attention!
The number of old line 6 is changing to 66.

The old line to Mt. Scopus has been cancelled, see alternatives on page 6

Line 66 from Chomut Shmuel does not reach Malcha. You can take new line 66A.

Legend:
- Blue dot of origin's destination
- Street finishes
- Rail station
- Area of change

- Green dot of origin's destination
- Street begins
- Rail station
- Rail station

Line 44 leaves from Chomut Shmuel to the Central Bus Station via Kfar Hamemishala

Tram Line 44 leaves from Chomut Shmuel to the Central Bus Station via Kfar Hamemishala

Bar-Ilan University

האוניברסיטה בר-אילן
Data sources

- GTFS based data
  - Routes
  - Stops
  - Trips & stop-times
  - Calendar
- Population per zone
- Road layer (for visualization)
<table>
<thead>
<tr>
<th>Origin</th>
<th>Destination</th>
<th>Hospital</th>
<th>Travel Time</th>
<th>Industrial Zone</th>
<th>Travel Time</th>
<th>High-tech Park</th>
<th>Travel Time</th>
<th>Municipality</th>
<th>Travel Time</th>
</tr>
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<tbody>
<tr>
<td>Quarter 1</td>
<td></td>
<td>Feb 4.1</td>
<td>June 4.3</td>
<td>Feb 4.4</td>
<td>June 4.4</td>
<td>Feb 8.0</td>
<td>June 8.3</td>
<td>Feb 7.9</td>
<td>June 7.7</td>
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<tr>
<td></td>
<td></td>
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<td>Feb 16.8</td>
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<td>Feb 5.0</td>
<td>June 6.7</td>
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<td></td>
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<td>June 5.5</td>
<td>Feb 12.0</td>
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<td>Feb 16.6</td>
<td>June 17.1</td>
<td>Feb 10.1</td>
<td>June 14.6</td>
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<tr>
<td></td>
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<td>71</td>
<td>40</td>
<td>49</td>
<td>26</td>
<td>27</td>
<td>34</td>
<td>26</td>
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<td>Quarter 8</td>
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<td>June 7.1</td>
<td>Feb 15.2</td>
<td>June 15.3</td>
<td>Feb 18.7</td>
<td>June 18.8</td>
<td>Feb 15.1</td>
<td>June 14.6</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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<td>72</td>
<td>60</td>
<td>68</td>
<td>60</td>
<td>57</td>
<td>51</td>
<td>46</td>
</tr>
</tbody>
</table>

For selected destinations. Green – significant improvement, Red - significant decline.
Spatial analysis

Industrial Zone

Accessibility is mostly with a transfer

Direct trips

Indirect trips

Direct + Indirect trips
Spatial Change Analysis

Summary
Subtracts the value of the second input raster from the value of the first input raster on a cell-by-cell basis.

Illustration

\[
\begin{array}{cccc}
1 & 1 & 0 & 2 \\
1 & 2 & 2 & 3 \\
4 & 0 & 2 & 0 \\
2 & 0 & 1 & 1 \\
\end{array}
\]

\[
\begin{array}{cccc}
3 & 1 & 0 & \text{Value = NoData} \\
3 & 1 & 2 & \text{Value = NoData} \\
0 & 2 & 0 & \text{Value = NoData} \\
1 & 2 & 1 & \text{Value = NoData} \\
\end{array}
\]

\[
\begin{array}{cccc}
1 & 0 & -1 & 0 \\
2 & 1 & 0 & \text{Value = NoData} \\
0 & 0 & 0 & \text{Value = NoData} \\
1 & 2 & 1 & \text{Value = NoData} \\
\end{array}
\]

=
Change in direct trips

The difference between the two periods:
Blue – increase (higher frequency)
Red – decrease (lower frequency)
Change in travel time

The difference between the two periods:
Green – decreased travel time
Red – increased travel time
The answer

- I don’t know!
Thanks

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