SampaNoShape

São Paulo Bus Movement Model

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São Paulo Bus System:
- Number of vehicles: ~14,400
- Number of bus routes: ~2,271
- Contractual value: R$ 66 billion (20 years)
- Passengers transported per workday: 6 million
- Passengers transported in 2017: 2.86 billion

Processed data:
- Number of monitored vehicles: 14,139
- Number of monitored bus routes: 2,183
- Monitored period: 1 week + 1 atypical day

Imagen: Marcelo Camargo - Agência Brasil
Simulation [bridging planning-reality gap]

“A simulation can show to city planners the behaviour and dynamics of the city in different hypothetical scenarios.” [Santana et al.]

Models based on real bus service data recreating mobility aspects of São Paulo

- Simulating bus movement patterns of each week day
- Evaluating impacts of seasonal bursty period
- Helping government agencies to plan changes in the bus infrastructure
InterSCSimulator

[traffic simulator for smart cities]

Documentation: http://interscity.org/software/interscsimulator/
Innovation startup, focused on smart cities and particularly on urban mobility issues

Develop products for:

- Government
- Citizens (passenger)
- Bus operators
- Companies

**Data Source**

**SPTrans**
São Paulo bus transit authority

**GTFS**
Data Source

Scipopulis

Bus trips metadata
● Initial bus stop
● Start time of a trip
● Reference date

Edges metadata
● Stop From and To
● Edge length
● Shapes

Log edges speed
● Bus average speed for each edge per hour

SPTrans

Bus trips metadata
● Stops sequence
● Bus schedule

Stops metadata
● Coordinates of location
Architecture
Main Challenges [of model construction]

- Matching Scipopulis and SPTrans data
- High data processing demand
- Elaborate strategies to deal with missing data
- Select relevant characteristics to be included in the model
- Make a good visualization to illustrate the insights
## Goal
To investigate differences between real and planned schedule

## Data Analysis [bus schedule]

**Case study**
1. Line 675K-10
   [Term Jd. Ângela > Metrô Sta. Cruz]
2. 856R-10
   [Socorro > Lapa]
3. 4210-10
   [Cid Tiradentes > Pqe. Dom Pedro]
4. 4311-10
   [Term S. Mateus > Pqe. Dom Pedro]

### Difference between real and planned frequency

![Graph showing frequency differences between real and planned schedule for different bus lines.](image-url)
Data Analysis [average speeds between stops]

2017, Oct 26th (Thursday)

Maximum speed at a) local streets [30 km/h] / b) bus corridors [50 km/h]

Maximum speed at:

- a) local streets [30 km/h]
- b) bus corridors [50 km/h]
Data Analysis [average speeds between stops]

2017, Apr 13rd, (Thursday, Atypical day: Easter eve)

7:00

12:00

17:00
Goal
To investigate how travel times vary through the day for lines which connects peripheral to central areas

Case study
Line 675K-10
[Term.Jd.Ângela > Metrô Sta. Cruz]
2017, Oct 26th, 7:00 am (Thursday, morning peak)

Goal
Investigating headway patterns (bunching x delays)

Case study
Line 675K-10
[Term. Jd. Ângela > Metrô Sta. Cruz]

Data Analysis [headway regularity]
Data Analysis [headway regularity]

2017, Oct 26th, 7:00 am (Thursday, morning peak)

### Schedule per stop

<table>
<thead>
<tr>
<th>Term.</th>
<th>06:58</th>
<th>07:05</th>
<th>07:07</th>
<th>07:08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jd.Ángela</td>
<td>07:04</td>
<td>07:05</td>
<td>07:07</td>
<td>07:08</td>
</tr>
<tr>
<td>Metrô Sta. Cruz</td>
<td>07:01</td>
<td>07:03</td>
<td>07:05</td>
<td>07:06</td>
</tr>
</tbody>
</table>

### Data Analysis

[headway regularity]

#### Case study

**Line 675K-10**

[Term.Jd.Ángela > Metrô Sta. Cruz]

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### Headway per stop

<table>
<thead>
<tr>
<th>Schedule - Time (Fig. 1)</th>
<th>Headway per stop</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Headway at the stop is the same</strong></td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Headway at the stop is higher</strong></td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Headway at the stop is shorter</strong></td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Bunching</strong></td>
<td>2.0</td>
</tr>
</tbody>
</table>

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14
2017, Oct 26th, 7:00 am (Thursday, morning peak)

Case study
Line 675K-10
[Term.Jd.Ângela > Metrô Sta. Cruz]

Data Analysis [headway regularity]

Headway pattern - between the 15th and 38th stops, the headways show larger variations

Headway disequilibrium
The Bus Movement Model [buses.xml]

<?xml version="1.0" ?>
<scsimulator_buses>

[...

<bus id="856R-10-0" interval="0,0,0,0,1200,....,1800" start_time="22150"
    stops="4814577,4811359,....,810011966,810011968,810011969"/>

<bus id="856R-10-1" interval="1800,0,0,0,3600,..,1200" start_time="23697"
    stops="810011969,810011967,....,480014609,480014963,4814577"/>

[...]

</scsimulator_buses>
The Bus Movement Model [map.xml]

<?xml version="1.0" ?>
<network>

<nodes>
 [...]
<node id="7906161" x="333228.6324660926" y="7386859.503655812"/>
 [...]
</nodes>

<!---------------------------------------------------------------------------------------------------------------------------------->

<links capperiod="01:00:00" effectivecellsize="7.5" effectivelanewidth="3.75">
 [...]
<link avgspeed="22.19, 21.42, ... , 12.88, 14.47, 18.27" from="790016357" to="790016218" length="323" linkId="790016357-790016218" shapeLat="332442.8428304753, ... , 332632.9512607706" shapeLng="7386061.151484802, ... , 7386274.432584263" />
 [...]
</links>
</network>
Conclusion [a future of possibilities]

**Future works**

Looking for better strategies to fill gaps in bus travel records, making analysis faster and more reliable

**Potentials**

The model we developed provides a more realistic input for simulating mobility planning, allowing better city traffic analysis, for example:

- Recreating the past, in order to analyse what happened
- Measuring the impact of changes in the city infrastructure
- Alternative routes analysis
- Comparison of potential interventions in the traffic