Integration of the global positioning system and geographical information systems for traffic congestion studies

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Background

Congestion

Experiments

Relation to Our Project

Strong and Weak Points

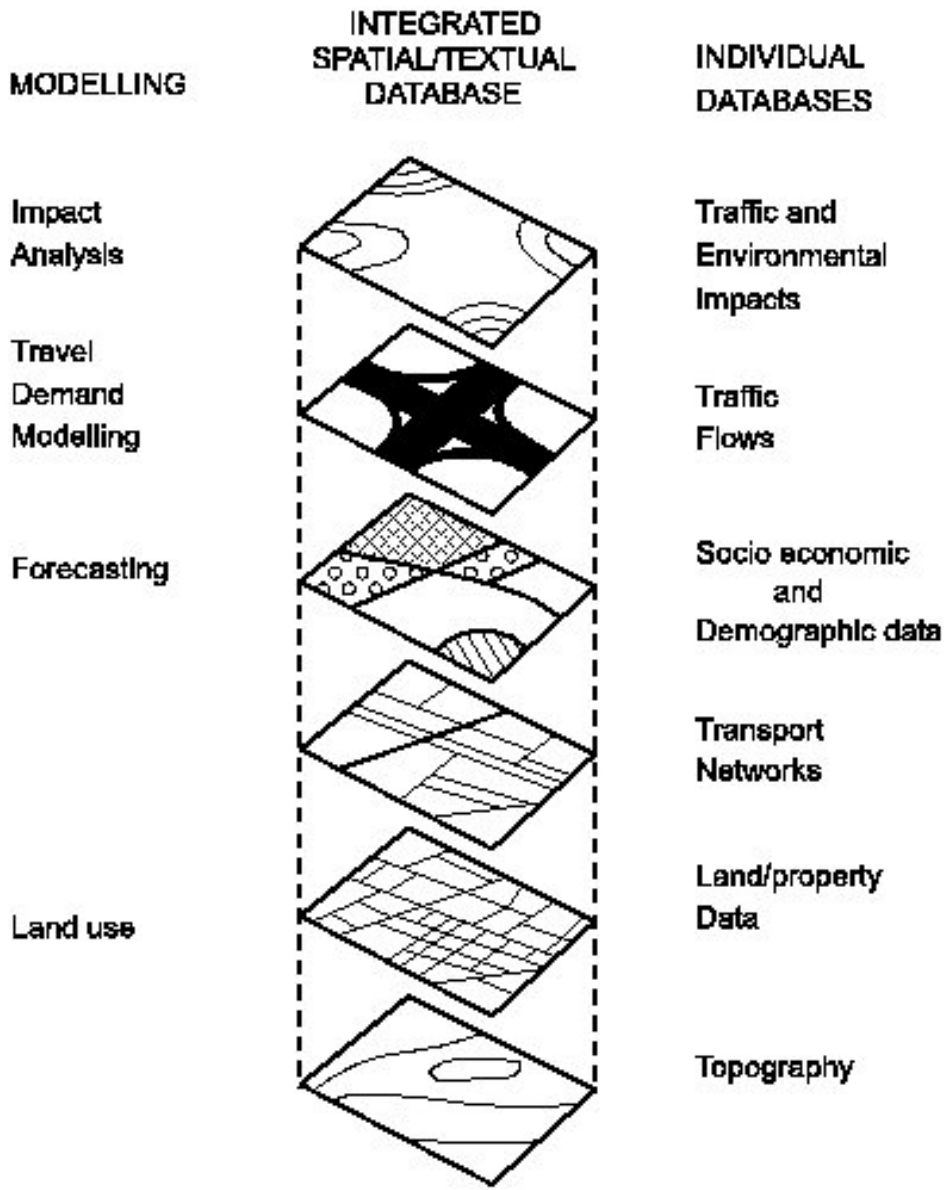
GPS/GIS Integration

- Idea: Combine GPS-data with other data sources
- Why: Traffic studies (ex. travel times, congestion), enviromental studies and planning
- How: Integrated GPS/GIS (Geographical Information Systems)

GPS/GIS Integration

- GPS-data (longitude, latitude)
- Enviromental data (emissions, engine revolutions, gear, fuel consumption)
- Geographical data (topography, land-data)

GPS/GIS Integration



Probe Vehicle

- GPS equipped car
- Additional equipment for recording ex. fuel consumption, engine revolutions and gear
- Expensive, not stock equipment

Table 1
Vehicle parameters logged in real time by the TSC probe vehicle

Variable	Measurement units	Variable	Measurement units
Time	s	Air conditioning	on/off
Distance	m	Power/economy mode	on/off
Speed	km/h	Engine gear	gear (1–4)
Fuel consumption	l	Hydrocarbons (HC)	ppm
Engine revolutions	rpm	Nitrogen oxides (NO_x)	ppm
Manifold pressure	Pa	Carbon monoxide (CO)	ppm
Throttle position	ratio	Carbon dioxide (CO_2)	ppm
Engine temperature	°C	Oxygen (O_2)	ppm
GPS position	Latitude + Longitude		

Moving Observer

- Appropriately equipped vehicle
- Records ex. travel times and queue lengths
- Represents the average driver
- Should traverse each route several times

Floating Car

- Is a moving observer
- Floats naturally through traffic
- Aims at being the "average" driver
- Should overtage the same number of cars as overtaken by
- Limits moving observer bias

Floating Car

- Mean travel time

$$\bar{t_{ab}} = t_{ab} + \frac{O}{q}$$

, where $\bar{t_{ab}}$ is the travel time, t_{ab} is the recorded travel time, O is the number of cars overtaken minus the number of cars who overtake and q is the mean flow rate.

- Mean flow rate is calculated by having a second vehicle traveling in the opposite direction

$$q = \frac{m - O}{t_{ab} + t_{ba}}$$

, where m is the number of cars met and t_{ba} is the travel time for the opposite direction.

Congestion

- Congestion is traffic jams
- Congestion is a major issue in traffic both for drivers and planners
- When is a road congested?
- And how much?

Definition of Congestion

- Increased disruption of traffic movement
- Results in delays and queues
- "Is generated by the interactions amongst the flow units in a traffic stream or in intersecting traffic streams"
- Visible when the capacity of a road is exceeded

Congestion Measures

- Delay is when the recorded travel time is greater than the free-flow travel time

$$d = T - T_0$$

, where T is the recorded travel time and T_0 is the free-flow travel time.

- Congestion can be measured using different methods:
  - Congestion Index
  - Proportion Stopped Time
  - Acceleration Noise

Congestion Index (CI)

- Delay on a piece of road will depend on the length of the road, road type and other characteristics
- CI enables comparison between roads with different characteristics
- Congestion Index is derived from Delay

$$CI = \frac{d}{T_0}$$

- A road or route will naturally have a CI of 0 in a state of free-flow
- The higher the CI gets, the more congested the road or route is

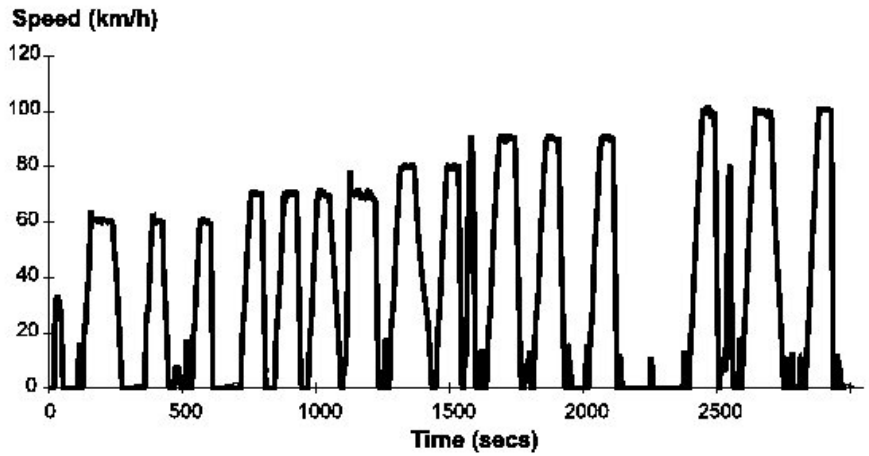
Proportion Stopped Time (PST)

- Travel time can be diveded into running time T_r and stopped time T_s
- PST is the ratio of stopped time to the total journey time

$$PST = \frac{T_s}{T}$$

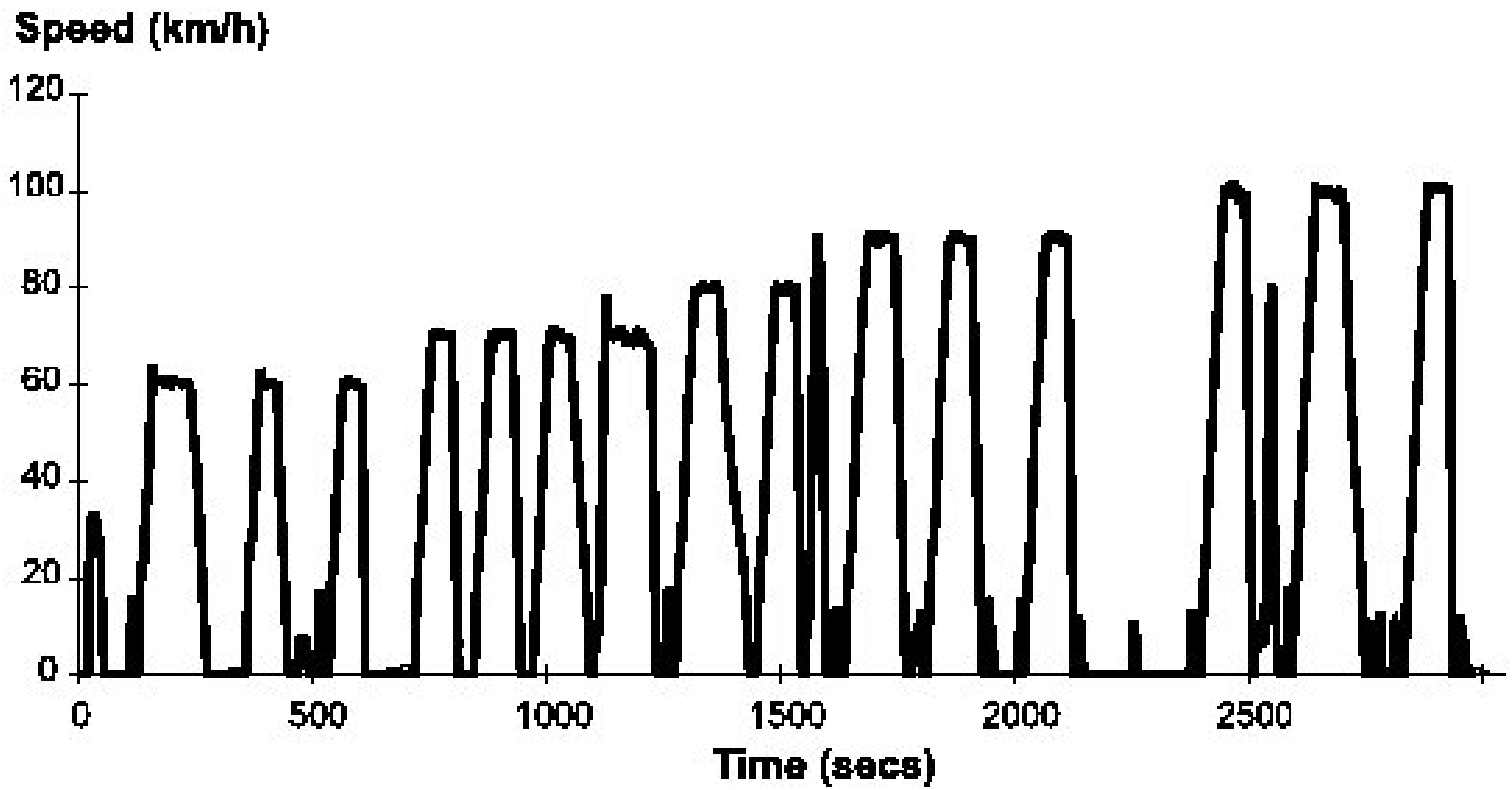
, where T is $T_s + T_r$

- Unlike CI, PST is usually not 0 as intersections will often induce stopped time



Acceleration Noise (AN)

- Acceleration Noice is calculated from a speed profile
- Idea: Congestion will induce more fluctuation in speed



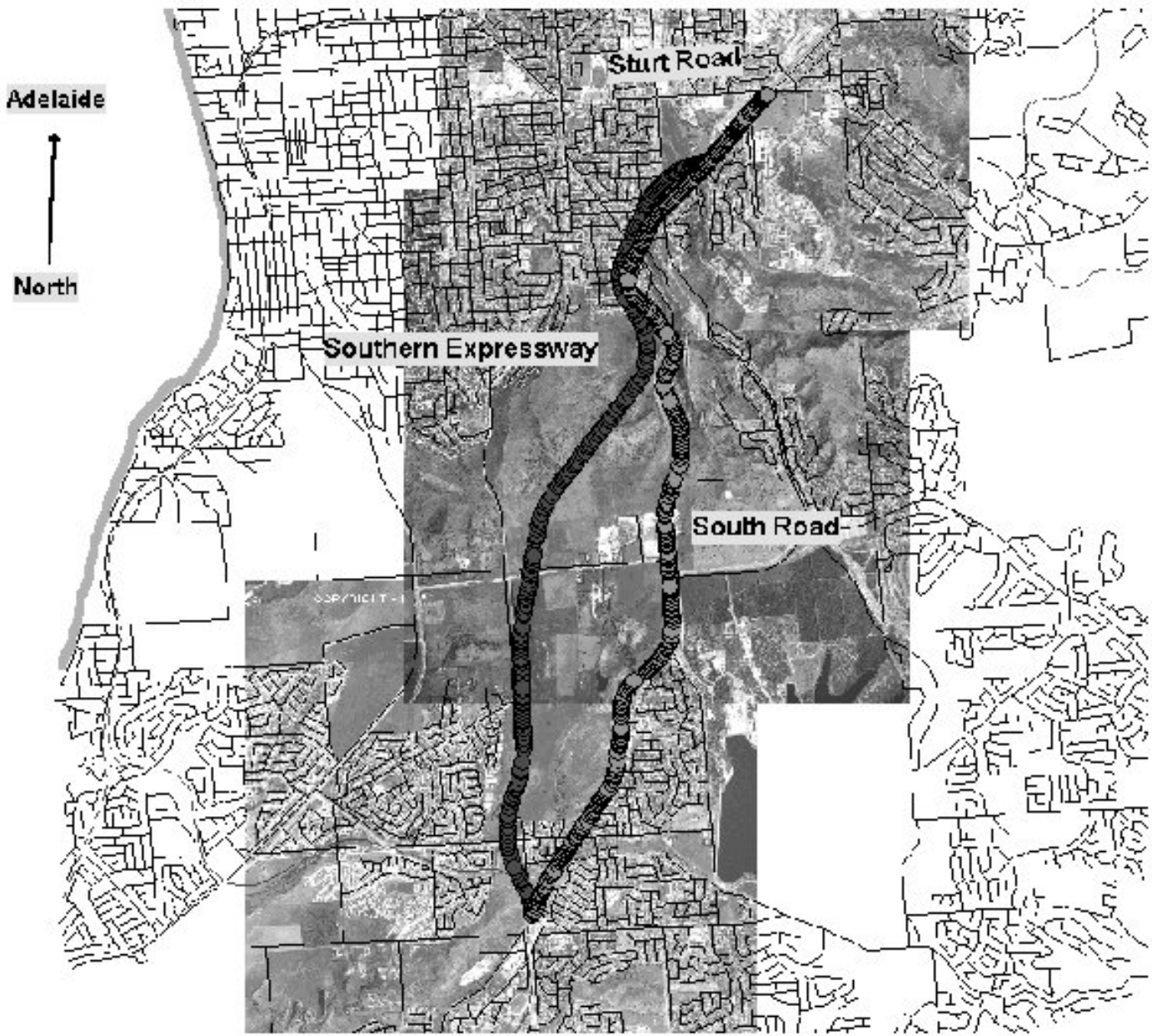
Acceleration Noise (AN)

$$AN = \sqrt{\frac{1}{T_r} \sum_{i=1}^{n} \frac{\Delta v_i^2}{\Delta t_i}}$$

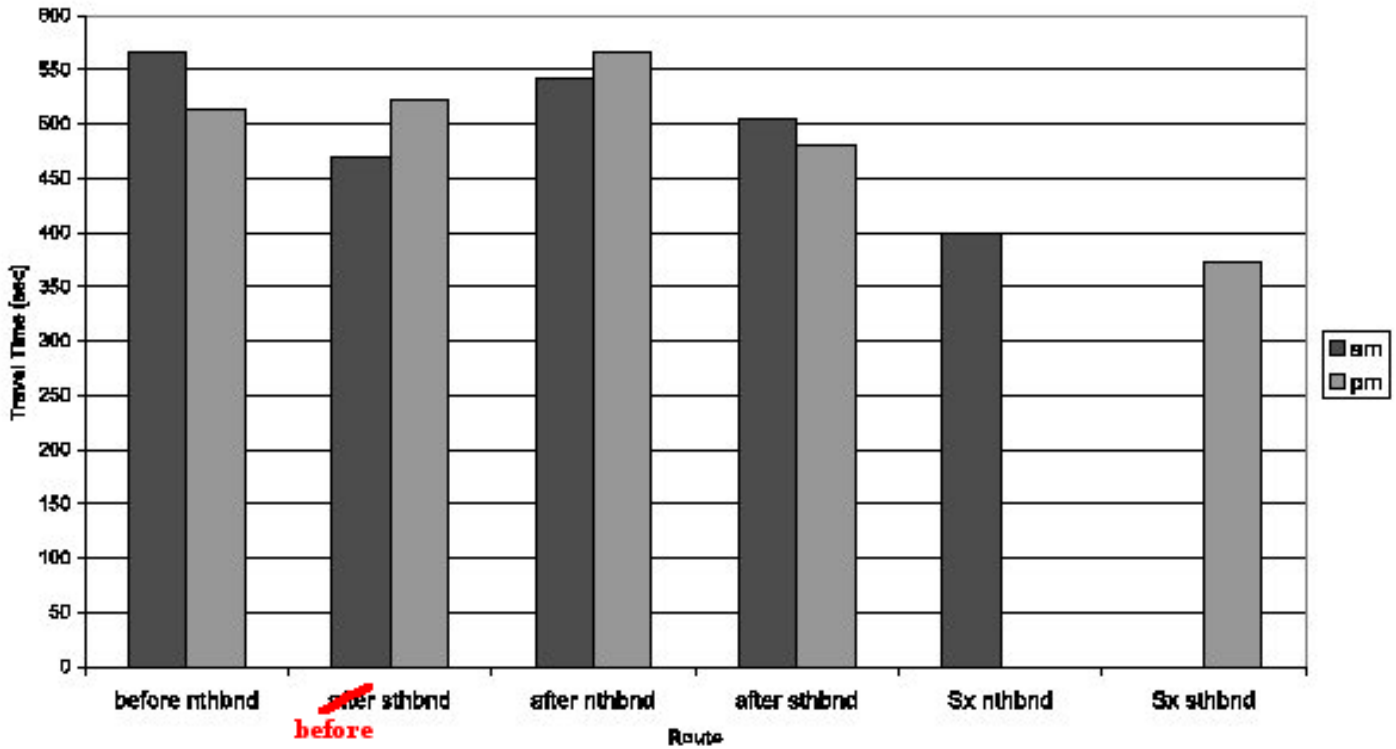
, where Δt_i is the time interval taken for a speed change Δv_i

- AN is different from CI and PST in that it provides a measure of the quality of the traffic flow
- AN is data-hungry as it requires prior knowledge about speed profiles on a specific road or route

Experiment setup



Experiments



- Construction of the new road does not consequently lower the travel times
- Travel times on the new road are lower, but the problems on the old road are not gone

Results

Table 4
Congestion indices for the Southern Expressway

Run code	Total distance (m)	Travel time (s)	Stopped time (s)	Mean journey speed (km/h)	Proportion stopped time	Acceleration noise	Mean velocity gradient	Congestion index
Morning peak direction		*Southern Expressway, free travel time* = 326.0 s, *all data collected in period* 07:00–09:00						
301198amn1	8154.7	424.0	22.0	69.2	0.052	0.459	0.024	0.301
3011981mn3	8149.1	374.0	0.0	78.4	0.000	0.420	0.019	0.147
011298amn2	8141.8	469.0	61.0	62.5	0.130	0.548	0.032	0.439
011298amn4	8166.4	396.0	11.0	74.2	0.028	0.574	0.028	0.215
021298amn1	8142.8	365.0	0.0	80.3	0.000	0.481	0.022	0.120
021298amn3	8164.9	416.0	29.0	70.7	0.070	0.515	0.026	0.276
021298amn5	8167.6	376.0	18.0	78.2	0.048	0.440	0.020	0.153
031298amn1	8165.3	350.0	0.0	84.0	0.000	0.494	0.021	0.074
031298amn3	8153.3	378.0	0.0	77.7	0.000	0.400	0.019	0.160
031298amn5	8150.7	454.0	70.0	64.6	0.154	0.581	0.032	0.393
041298amn2	8144.2	379.0	5.0	66.4	0.013	0.473	0.022	0.163
041298amn4	8155.8	421.0	57.0	69.7	0.135	0.562	0.029	0.291
041298amn5	8158.9	382.0	24.0	76.9	0.063	0.503	0.024	0.172

Our project

- Estimate travel times based on GPS-data collected by ex. cars and taxis
- Calculate fastest path from A to B for a number of A's and B's
- Identify/handle troublesome events such as rush hour

Relation to Our Project

- Our project is only concerned with traffic, not environment and other aspects
- We use multiple data collection vehicles which do not "float" but are moving observers
- We base our solution on travel time estimated from GPS-data, but not in the same way
- We might be able to use some of the congestion measures
  - Delay, CI and PST can be calculated using the data we receive, but might not be usable. We might need to do someting like PST.
  - Given enough data we can use AN or speed profiles. We might store travel times in a manner that resembles speed profiles.

Strong and Weak Points

Strong points:

- Clear definitions of congestion measures
- Nice overview of GPS/GIS integration
- Practitally usable experiments

Weak points:

- No clear contributions
- Data collection is based on a single probe vehicle
- Experiments could have been compared to the models used when designing the new road

Questions?