Dynamic Travel Time Maps - Enabling Efficient Navigation

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Outline

The Challenge

Problem

The travel-time in road networks is calculated based on static information (length/speed limit).

Solution

Use historical data (map-matched GPS positions) to argument the road network with additional statistical information.

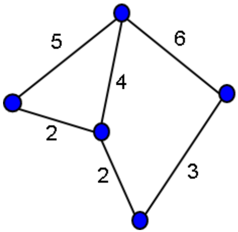
Challenge

If there is not historical data for all roads how to compensate for that (spatial and temporal)?

Outline

- Background
- Travel Time
- Data Model
- Experimental Evaluation
- Strong and Weak Points

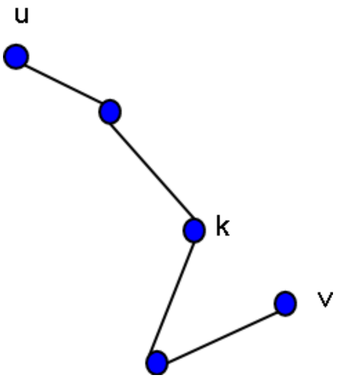
Road Network



- $G = (V, E)$
  - V = vertexes
  - E = edges
- weight function $w : E \longrightarrow R$

Shortest Path + Algorithms

- Any path p between u and v with weight $w(p) = \delta(u, v)$
- Dijkstra
  - Complete and optimal result
- A*
  - Uses heuristics
  - "Informed search algorithm"
  - Uses shortest path estimate
  - $\delta(u, v) = \delta(u, k) + h(k, v)$
  - Lower bound for $h(k, v)$ based on Euclidean distance

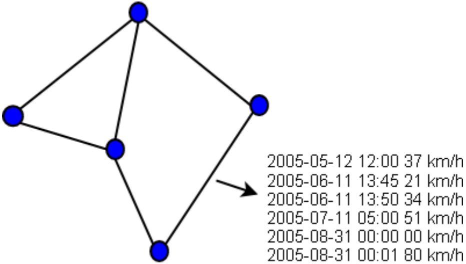


Static and Dynamic Weights

Static (the current usage)

- Road categories and associated speed limits
- Sometimes speed types based on road-side survey (expensive)

Dynamic



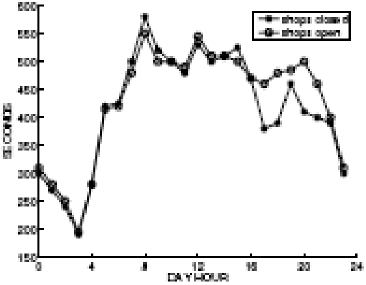
- Use massive amounts of historical floating car data (FCD)
- Assume causality between historical and current traffic conditions
- Edges without associated historical data must be handled

Advantages Dynamic Weights

- Increased accuracy of computed travel times
- Can change the underlying data foundation for the routing algorithm at run time
- In a specific routing scenario: if discrepancy between computed and actual travel-time, recompute the route with newer information

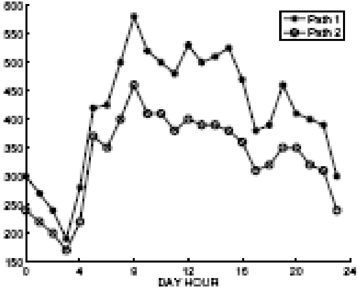
Outline

Temporal Causality



- For a given path the travel-time exhibits recurrent behavior
- Examples
  - rush-hour, non-rush-hour, night
  - workday, holiday, weekend

Spatial Causality



- Travel time for different edges are similar over time
- Examples
  - Driving in Aalborg's suburbs Visse, Svenstrup and Gistrup is similar
  - Driving on multiple roads in downtown Aalborg have similar travel-time patterns

In the paper

- based on spatial proximity
- based on road category

Characteristic Travel-Time

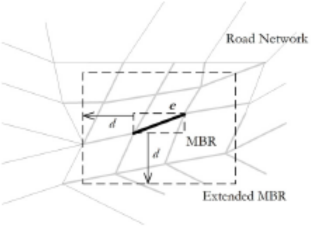
- $P(e)$ = set of relative travel-times to edge e
- $X(P)$ = characteristic travel-time
  - cardinality
  - statistical mean
  - variation

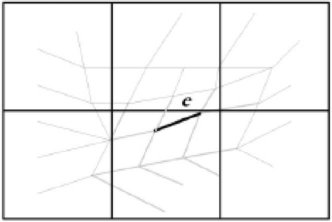
How to determine the set $P(e)$?

- Temporal inclusion $I_T(e)$
- Spatial inclusion $I_S(e)$

Spatial Inclusion

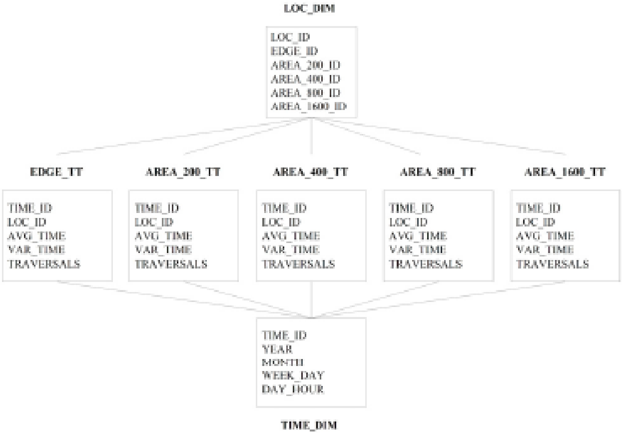
- Simple
- Neighborhood
  - Contained in MBR
  - Same road category
- Tiling
  - Edges belonging to the same tile
  - Same road category





Outline

Dynamic Travel-Time Map



- Spatio-temporal data warehouse
- Neighborhood method => range query
- Note: spatial hierarchy, temporal granularity, facts

Outline

Setup

- 108,000 vertexes, 150,000 edges
- 26,000 trajectories
- 11 million segments
- Sample rate 30 seconds

Edge types

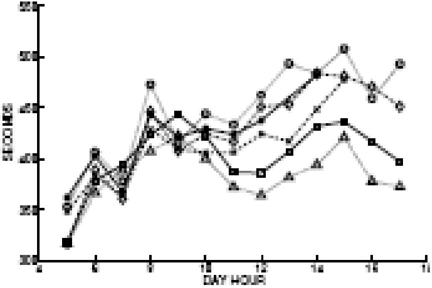
- Frequently traversed
- Non-frequently traversed

Paths in Experiments

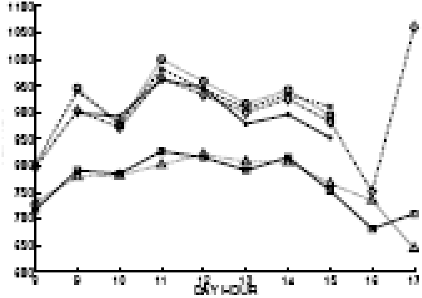
Path id	Length (km)	Frequency %
1	2.0	50
2	4.5	42
3	2.2	13

Accuracy

Path 1

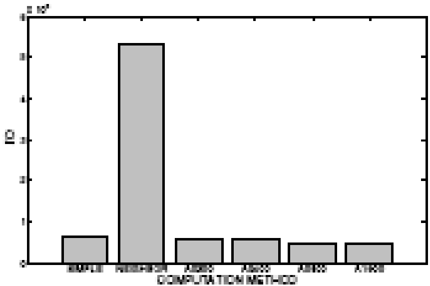


Path 2

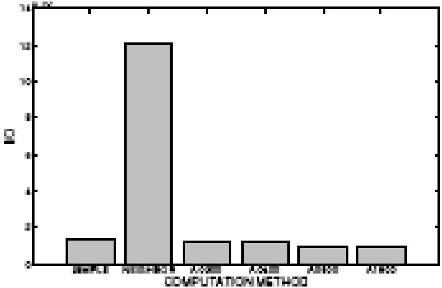


Computation Cost

Path 1



Path 2



Outline

Strong Points

- Proposes a model for dynamic travel-time calculation
- Includes data model
- Spatial inclusion a good idea for solving missing data
- Validation using three paths

Weak Points

- No comparison of computed travel-times to actual travel-times
- Details about spatial inclusion
- Star-schema very simple (too simple?)
- Temporal granularity hours (too high?)