Towards Better Urban Travel Time Estimates Using Street Network Centrality

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Problem Statement

We want to:

1. Predict travel time / speed on a certain road at a certain time
2. Where we don’t have measurements
3. Using only street network data – NO travel demand data
Travel Time Prediction

Usual approaches:

- Sensor measurements
- Traffic model
- Fallback: Speed limit \times correction factor
Our Basic Prediction Model

Explanatory Variables:
- Time of day
- Road class
- Speed limit
Centrality

1. Closeness: “Central” $\leftrightarrow$ “Peripheral”
   
   How far is it to all other network nodes?

2. Betweenness: “Important” $\leftrightarrow$ “Unimportant”

   How often is this location on the shortest paths between network nodes?
Global Closeness
Local Closeness
Global Betweenness
Local Betweenness
Linear Regression Model

Standard linear ordinary least square (OLS) regression model

\[ Y = X\beta + \varepsilon \]

where

\[ \hat{\beta} = (X^TX)^{-1}X^TY \]

Estimators:

\[ \hat{y}_{t,f} = \beta_t + \beta_{f,s} \cdot s + \beta_{f,b} \cdot b + \beta_{f,c} \cdot c + \beta_{f,bc} \cdot b \cdot c \]

Where

- \( Y \) … Speed records
- \( X \) … Model matrix (daytime t, frc f, betweenness b, closeness c, speed limit s)
- \( \hat{\beta} \) … stacked vector of
  - OLS estimates \( \beta_t, \beta_{f,s}, \ldots \)
- \( b \) … betweenness
- \( c \) … closeness
- \( s \) … speed limit
- \( \varepsilon \) … Residual
Centrality Model Parameters

\[ \widehat{y}_{t,f} = \beta_t + \beta_{f,s} \cdot s + \beta_{f,b} \cdot b + \beta_{f,c} \cdot c + \beta_{f,bc} \cdot b \cdot c \]

Secondary & tertiary roads  Local roads & residential streets

Central

Peripheral

Unimportant

Important
Result 1: Improved Coverage of Estimators

Boxplots of speed records and model estimates
Secondary & tertiary roads with speed limit 50 kph
Interpretation of Results

1. Base model
2. 1\textsuperscript{st} extension using \textit{global centrality}
3. 2\textsuperscript{nd} extension using \textit{local centrality}
Mean Percentage Error

Base Model

MAPE

- 0 to 5
- 5 to 10
- 10 to 20
- 20 to 30
- 30 to 50
- 50 to 60
- > 60
Mean Percentage Error

2nd Extended Model
Mean Percentage Error

Base Model
Mean Percentage Error

2nd Extended Model
Improvements using Global Centrality

8.5%
Improvements using Local Centrality

14%
Difference between Global & Local Centrality

6%
Model Performance Summary

Minimum Measurement Count

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Model
- base
- global
- local
Contact

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