Level of service estimation at traffic signals based on innovative traffic data services and collection techniques

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Motivation

Network-wide LOS estimation at traffic lights
  - e.g. approach delays and avg. travel speeds

Initial situation:
  - Limited applicability of conventional techniques like:
    - Analytic calculations / Simulations
  - Insufficient coverage of conventional data collection techniques like:
    - Stationary detectors (loops, cameras etc.)
Innovative data sources

Traffic data service provider:

Field of activity: Collect, handle, store und distribute spatial traffic flow information

Analyzed traffic data service provider:
## Innovative data sources

**Traffic data service provider:**

Data sources:

<table>
<thead>
<tr>
<th>Historical traffic information</th>
<th>Realtime traffic information</th>
<th>Predictive traffic information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary data sources</td>
<td>Mobile data sources</td>
<td>Meta data</td>
</tr>
<tr>
<td>Local detectors</td>
<td>Floating Car Data (FCD)</td>
<td>Traffic jam information</td>
</tr>
<tr>
<td></td>
<td>Floating Phone Data (FPD)</td>
<td>Events</td>
</tr>
</tbody>
</table>

Traffic information of data service providers

- Traffic data service provider:
  - Data sources:
    - Historical traffic information
    - Realtime traffic information
    - Predictive traffic information
      - Stationary data sources
        - Local detectors
      - Mobile data sources
        - Floating Car Data (FCD)
        - Floating Phone Data (FPD)
      - Meta data
        - Traffic jam information
        - Events
## Innovative data sources

### Traffic data service provider:

Derivable performance measures
- Average through-vehicle travel speed related to TMC locations or links
  - TMC Location $\rightarrow$ approx. avg. approach delay (best case)
  - Link $\rightarrow$ approx. avg. approach delay and avg. total delay

### Spatial referencing:

- **Link**
  - Company specific referencing
  - Detailed spatial travel speed information

- **TMC location**
  - Controlled by national authority
  - Rough spatial travel speed information
Innovative data sources

Traffic data service provider:

Example:

Heatmap of single links

<table>
<thead>
<tr>
<th>LOS [-]</th>
<th>avg. travel speed [km/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≥ 40</td>
</tr>
<tr>
<td>B</td>
<td>≥ 30</td>
</tr>
<tr>
<td>C</td>
<td>≥ 25</td>
</tr>
<tr>
<td>D</td>
<td>≥ 20</td>
</tr>
<tr>
<td>E</td>
<td>≥ 15</td>
</tr>
<tr>
<td>F</td>
<td>&lt; 15</td>
</tr>
</tbody>
</table>

LOS matched TMC location
Innovative data sources

Local, temporary collection techniques
- Detailed collection of different performance measures
- Individual advantages and disadvantages related to their principle of function

Automatic number plate recognition
- Average through-vehicle travel speed
- Average approach delay, total delay
- Percentage of driving without stopping

GPS-Tracking
- Average through-vehicle travel speed
- Average approach delay, total delay
- Percentage of driving without stopping
### Developed two stage concept

**1. Stage: Network-wide LOS estimation**

Data source: (Data traffic service provider - TMC or Link referenced)

- Average through-vehicle travel speed (LOS)
- Average approach delay (LOS) (optional)
- Colored LOS related map
- Bottleneck identification and selection of traffic impaired road

![Network-wide LOS estimation](image1)

**2. Stage: Local LOS estimation**

Data source: (Local, temporary collection techniques - ANPR / GPS)

- Validation of traffic data service
- Positiv validation → further investigations
- Information from the validation → impaired intersections and road segments
- Complete collection of performance measures for impaired intersections
- Complete overview over performance measures

![Local LOS estimation](image2)
Developed concept

Real-World case study

1. Stage: Network-wide LOS estimation for Hannover
   - Lowest avg. travel speed during a typical weekday (e.g. typical Monday)
   - based on traffic data service provider

- LOS-A $\Rightarrow V \geq 40$ km/h
- LOS-B $\Rightarrow V \geq 30$ km/h
- LOS-C $\Rightarrow V \geq 25$ km/h
- LOS-D $\Rightarrow V \geq 20$ km/h
- LOS-E $\Rightarrow V \geq 15$ km/h
- LOS-F $\Rightarrow V < 15$ km/h

does not exist
Real-World case study

1. Stage: Selection of travel speed impaired TMC location
   - Hildesheimer Str., main arterial (LOS D)

   - 4 traffic-actuated pedestrian crossings
   - 3 traffic-actuated intersections
Real-World case study

1. Stage: Selection of travel speed impaired TMC location
   - LOS related colored map shows only the typical Monday
   - Lowest avg. travel speed on Monday between 08:00 - 09:00 a.m. (LOS D)
Developed concept

Real-World case study

1. Stage: Calculation of avg. approach delays based on traffic data service
   - Basic principle: Time difference between $V_{ff}$ and $V_{traffic data service}$

<table>
<thead>
<tr>
<th>Intersection</th>
<th>avg. approach delay [s]</th>
<th>LOS [-]</th>
</tr>
</thead>
<tbody>
<tr>
<td>pedestrian crossing 1</td>
<td>4,7</td>
<td>A</td>
</tr>
<tr>
<td>pedestrian crossing 2</td>
<td>3,2</td>
<td>A</td>
</tr>
<tr>
<td>intersection 1 (Peiner Str.)</td>
<td>20,9</td>
<td>B</td>
</tr>
<tr>
<td>pedestrian crossing 3</td>
<td>4,3</td>
<td>A</td>
</tr>
<tr>
<td>intersection 2 (An der Wollebahn)</td>
<td>15,0</td>
<td>A</td>
</tr>
<tr>
<td>pedestrian crossing 4</td>
<td>8,7</td>
<td>A</td>
</tr>
<tr>
<td>intersection 3 (Garkenburgstraße)</td>
<td>8,2</td>
<td>A</td>
</tr>
</tbody>
</table>

**Conclusion:**
- Good performance of single approaches
- Most impair from Intersection 1

**Assumption:**
- Amount of intersections impairs the traffic flow!
Real-World case study

2. Stage: Validation of traffic data service

- Local, temporary data collection techniques
- ANPR $\rightarrow$ average through-vehicle travel speed on selected TMC location

Valid:
- Difference not bigger than one LOS
- LOS-D confirmed
Developed concept

Real-World case study

2. Stage: Local LOS estimation
   - GPS-Tracking
   - One Car ≈ 4 cycles per hour

<table>
<thead>
<tr>
<th>Intersection</th>
<th>GPS-Tracking</th>
<th>Data traffic service provider</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>avg. approach delay [s]</td>
<td>LOS [-]</td>
</tr>
<tr>
<td>pedestrian crossing 1</td>
<td>4,2</td>
<td>A</td>
</tr>
<tr>
<td>pedestrian crossing 2</td>
<td>17,2</td>
<td>A</td>
</tr>
<tr>
<td>intersection 1 (Peiner Str.)</td>
<td>63,8</td>
<td>D</td>
</tr>
<tr>
<td>pedestrian crossing 3</td>
<td>0,0</td>
<td>A</td>
</tr>
<tr>
<td>intersection 2 (An der Wollebahn)</td>
<td>18,4</td>
<td>A</td>
</tr>
<tr>
<td>pedestrian crossing 4</td>
<td>0,0</td>
<td>A</td>
</tr>
<tr>
<td>intersection 3 (Garkenburgstraße)</td>
<td>7,7</td>
<td>A</td>
</tr>
</tbody>
</table>
Conclusion

- Developed concept could be applied successfully
- Modern and useful method for future quality management of traffic lights