New intelligent control methods for traffic light systems (TLS) evaluated with DLR’s microscopic traffic simulator SUMO

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German Aerospace Center (DLR) at a glance

- Research focuses on the following areas
  - Aeronautics
  - Space
  - Energy
  - Transport
  - Security and Digitalization

- Approx. 8,200 employees across 40 institutes and facilities at 20 sites

- Offices outside Germany in Brussels, Paris, Washington and Tokyo
Simulation of Urban Mobility – SUMO
A microscopic transport and traffic simulation
SUMO – what is it?

• Is **open source**, licensed under the EPL (Eclipse Public License) v 2.0
• Comes with a complete suite of **helper programs** like TraCI
• Allows to:
  • simulate large cities and areas in **real-time**
  • import **travel demand** from external sources
  • import formats for **networks**: OpenStreetMap, PTV VISUM, PTV VISSIM, HERE, NavTeq

Current Version: 1.2.0
Website / Download: [http://sumo.dlr.de/](http://sumo.dlr.de/)
Contact: sumo@dlr.de
Under development: Since 2001
SUMO – what can be run?

- Exaggeration: “Any moving object in a city can be simulated with SUMO!”

- SUMO allows modelling of intermodal and multimodal traffic systems:
  - Cars,
  - Busses, Passengers,
  - Bicycles, Pedestrians,
  - Ships, Goods traffic,
  - Transport Chains (Containers etc.)
SUMO – who use it?

- Used world-wide, especially in the scientific community
- Active community with approx. 40,000 downloads in year 2019

**Total Downloads:**

1. China 6,229  
2. USA 4,698  
3. India 3,812  
4. Germany 3,577  
5. Brazil 1,503  

103. Uzbekistan 14

Source: sourceforge.net
VITAL - Vehicle-Actuated Intelligent Traffic Signal Control
Two new approaches for optimized signal control
Motivation / Expected advantages of the new approach

- **Reduction of Waiting and Travel Times for all traffic participants**
- **Avoidance of Emissions in terms of Climate Protection and a healthier Urban Environment**
- **Reduction of Financing Costs for Traffic Infrastructure by Municipalities**
Delay-based control

- Initial point: New ICT data sources
  - **V2X communication**
  - Video capturing
  - Wireless in-road detectors

- **Delay time**: is the additional travel time compared to the uninterrupted passing of an intersection

- Idea: **Stop a running green phase** as soon as all delayed vehicles on an approach have been served
GLOSA (Green Light Optimized Speed Advisory)
Co-operative control

- **GLOSA** – *signal time states* are send back to the vehicle
- **AGLOSA** (Agent-Aware) – combination of *vehicle-actuated traffic signal control* and vehicle-given speed recommendations
- V2X standard enables cooperative *bi-directional communication*
- Works with *short time prediction* of further movements and trajectories
Modified control logics

- Straightforward modification of the existing control strategy
- Only the criteria for **stopping a running green phase** is replaced
Delay-based control
First simulation results

• Several simulation studies on abstract systems in SUMO had been done

Simulation
Co-operative control
Additional Hardware

- **AGLOSA** algorithm requires a lot of computing resources
- **Embedded PC** is directly placed in the control cabinet
- SUMO is modelling the **state of traffic** in **real-time**
- **Point-based** vehicle detections will be transformed into **continuous** floating car data (FCD)

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**Embedded PC**

**SUMO simulation**

**Signal and detector states**

**Stop running green phase**

**TLC**

**Signal control logic**
Real-time simulation with SUMO
Example: Traffic light optimization / City of Hefei (China)
### Implementation in the Field

**Field study: Two test Intersections in Germany**

<table>
<thead>
<tr>
<th>Control Mode</th>
<th>Braunschweig</th>
<th>Halle (Saale)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vehicle-actuated green time adjustment with <strong>static</strong> signal program selection</td>
<td>vehicle-actuated green time adjustment with <strong>dynamic</strong> signal program selection</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Detection equipment</th>
<th>Braunschweig</th>
<th>Halle (Saale)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>induction loops</strong></td>
<td>(vehicle presence and headway detection)</td>
<td><strong>induction loops, radar and video detectors</strong> (vehicle presence and headway detection)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bus pre-emption</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Traffic load</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
</table>

| Typ of vehicles | cars, cyclists and pedestrians | cars, less cyclists and pedestrians |
Implementation in the Field

- Complexity: Medium
- Existing TLC (Siemens C900V) and equipment was used
- Additional Hardware:
  - 16 wireless magnetic in-road sensors for vehicle detection
  - 1 additional embedded PC for the co-operative control
  - 1 Road Side Unit for Car-to-Infrastructure Communication (V2X Protocol IEEE 802.11p)
Simulation demo case
Measured values
Mean loss time vs. demand

- Existing control methods
- Co-operative Signal Control
- Delay-based Signal Control

Demand scenario:
- Low: 23.1, 20.6, 20.3
- Medium: 27.4, 25.7, 23.7
- High: 31.3, 30.4, 26.2
Implementation in the Field

- Complexity: Low
- Existing TLC (Siemens C900V) and equipment was used
- Additional Hardware:
  - 11 wireless magnetic in-road sensors for vehicle detection
  - 1 additional embedded PC for the co-operative control
Simulation demo case
Measured values
Mean loss time vs. demand

- **Existing control methods**
- **Co-operative Signal Control**
- **Delay-based Signal Control**

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<tr>
<th>Demand Scenario</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.3</td>
<td>11.5</td>
<td>10.2</td>
<td>15.6</td>
</tr>
<tr>
<td>17.1</td>
<td>15.6</td>
<td>13.2</td>
<td>29.4</td>
</tr>
<tr>
<td>23.6</td>
<td>23.6</td>
<td>23.6</td>
<td>23.6</td>
</tr>
<tr>
<td>15.7</td>
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</tbody>
</table>

Mean loss time (s/veh)
Consideration of Vulnerable Road Users (VRU)
Consideration of Vulnerable Road Users (VRU)

- Interactive integration of **VRU Mobile Devices**
- Localization of non-motorized road users with **Bluetooth beacons**
- Provision of **GNSS correction data** via V2X protocol
- Data fusion enables **high-precision position information** from VRU
Environmentally-oriented traffic control
SMartAiRTracer for measuring fine dust (PM$_{10}$)
Conclusion

Two new methods reducing waiting and travel times for all traffic participants significantly.

Environmentally oriented traffic management decrease vehicular emissions.

Increasing V2X equipment rates (above 15%) will reduce costs for municipalities.
Thank you for your attention!

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