Investigation of the effect of AVs on the capacity of an urban transport network

Ronald Nippold¹, with Peter Wagner¹,², Olaf Angelo Banse Bueno¹ and Christian Rakow²

¹ German Aerospace Center (DLR) – Institute of Transport Systems
² Department of Transport Systems Planning and Telematics, Technical University of Berlin

SUMO User Conference 2021, Berlin, Germany
13 – 15 September 2021
Introduction

• Autonomous vehicles (AV) entering an operational stage

• Intensive testing of driving functions etc., partly on public roads

• Numerous research and demonstration projects, e.g.

  • Sensing systems (and communication) → expected increase in traffic safety and efficiency

Source: Wikipedia.org (CC BY-SA 4.0)
Aim and Motivation

- Data exchange between meso- and microscopic simulation → “semantic coupling”
- Extrapolation of locally observed effects of A(C)V on the overall traffic system (entire road network, public transport, combined use of different modes of transport)
- Consideration of both route, mode and departure time choices of demand
- Calculation of the traffic impacts and resulting environmental impacts
Scenario

- First question: capacities at traffic signal controlled intersections
- Area around the city of Düsseldorf, 900 km²
- Total length of all edges: about 13700 km
- Number of signal-controlled intersections: 1637
- Network based on raw OSM data, no post-processing → some network defects
Scenario – cont.

• Current set-up of the test site: no application of V2X communication technologies

• Approximate representation of AV by adapting the SUMO standard model of car-following for passenger cars → ref. table

• Analysis of all shares/combinations of CV and AV in 10% steps (0...100%)

• Parameters:
  • $b$: technical limitation to 3 m/s²
  • $\tau$: rather conservative, missing regulations
  • $\sigma$: latencies in signal processing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CV (default)</th>
<th>AV (adapted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>decel</td>
<td>7.5</td>
<td>3.0</td>
</tr>
<tr>
<td>tau</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>sigma</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>speedFactor</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>speedDev</td>
<td>0.1</td>
<td>0</td>
</tr>
</tbody>
</table>
Computation

- 1637 signal-controlled nodes, all of type="actuated"
- 17653 transit or turning lanes in total at these intersections
- 11 different shares of CV/AV
- Procedure:
  - Network parsing using sumolib
  - Intersection identification and creation of subsets
  - For each subset (of intersections): Traffic flow creation for each lane with the respective share of AV/CV using TraCI
  - (Parallel) simulation runs for 1 hour
  - Determination of resulting out flow with E1 detector
- Computation time: ~ 6 days creating 36 threads (on two different servers)
Results

- Typical histogram for resulting capacities at signal controlled intersections
- Comparison of 20% / 80% CV resp. AV
- Very low flows → network defects
- Very high flows → network particularities, e.g. intersections with different road categories
Results

• Typical histogram for resulting capacities at signal controlled intersections

• Comparison of 20% / 80% CV resp. AV

• Very low flows → network defects

• Very high flows → network particularities, e.g. intersections with different road categories
Results – cont.

• Plot of class means of peaks for all 11 shares of CV/ AV

• Almost linear increase of traffic flow with growing share of CV ($R^2 \approx 0.9$)

• 50%/ 50% CV resp. AV $\rightarrow$ max. disruption in traffic flow

• 0% and 100% AV differ noticeably by over 10% difference in traffic flow
Comparison with free flow on highways

• Plot of class means of peaks for all shares

• Three lanes per direction, road gradient < 1%, low amount of heavy duty traffic → $q_{\text{max}} \approx 5700$ veh/h

• Best fit by 3rd order polynomial (not symmetric)
Future research

• Modeling of effects of intelligent traffic infrastructure concepts directly in SUMO and transfer to the MATSim model

• Matching congestion patterns from simulation and data
Thanks for listening!