Combining Autonomous Vehicles and Controlled Events in Driving Simulator Experiments

Johan Olstam
• Driver behavior studies & driving simulators
• Surrounding traffic in driving simulators
• The play preparation problem
• The ideas behind the algorithm
• Test in the VTI Driving simulator
• Conclusions and future research
Driving behavior experiments

- Used to assess hypothesis
- Studying driver behavior in a specific context
- Follows traditional experimental design
- Limiting confounding variables is difficult

Can be conducted in
- Real world
- Test tracks
- Driving simulators

Combining autonomous vehicles and controlled...

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Driving Simulators

Safe and controlled experiments concerning e.g.

- Alcohol, medicines and drugs
- Driving with disabilities
- Technical systems (ADAS, IVIS, NOMAD, …)
- Fatigue
- Vehicle and road design

Combining autonomous vehicles and controlled...

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Two types of surrounding vehicles

”Fully controlled”
No own initiatives
“Enslaved”
Detailed instructions
Low driving skills

”Fully Autonomous”
Own initiatives/goals
React on the surroundings
No/few instructions
High driving skills
Driver behavior experiments

Real world/Actual experiment

As in actual driving but:
- More controllable
- Safer

"Fully" controlled driving simulator experiment

"Fully" autonomous driving simulator experiment

to get reproducibility

"Fully" controlled driving simulator experiment

Price is level of complexity & generalizibility

Increase complexity

Combining autonomous vehicles and controlled...

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The parts of a driving simulator Scenario

- Everyday life driving
- Preparations for directed Plays
- Directed Plays

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The play preparation problem

Create a pre-specified situation from an unknown traffic situation in a non-conspicuous way

Consists of:

• Casting of roles
• Transportation of actors (with roles) to the stage
• Transportation of actors (without roles) from the stage

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Aims

• test if the algorithm is able to reconstruct equal play start conditions for each participant in a non conspicuous way

• test if the type of traffic (autonomous or controlled) during the everyday life driving affects the participants’ driving behavior and/or experience of the drive.
Combining autonomous vehicles and controlled... 

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The participants

- 10 participants, in-house VTI personnel

<table>
<thead>
<tr>
<th>Participant number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
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<tbody>
<tr>
<td>Gender</td>
<td>F</td>
<td>M</td>
<td>M</td>
<td>F</td>
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<td>M</td>
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<tr>
<td>Age</td>
<td>36</td>
<td>37</td>
<td>53</td>
<td>50</td>
<td>60</td>
<td>29</td>
<td>43</td>
<td>58</td>
<td>25</td>
<td>32</td>
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<tr>
<td>Years with license</td>
<td>18</td>
<td>20</td>
<td>32</td>
<td>32</td>
<td>41</td>
<td>11</td>
<td>23</td>
<td>32</td>
<td>6</td>
<td>13</td>
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<tr>
<td>Mileage last year</td>
<td>1000</td>
<td>1200</td>
<td>1500</td>
<td>500</td>
<td>1000</td>
<td>3000</td>
<td>1500</td>
<td>1600</td>
<td>300</td>
<td>1000</td>
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<tr>
<td># of drives in simulator</td>
<td>0</td>
<td>15</td>
<td>3</td>
<td>0</td>
<td>3</td>
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<td>0</td>
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<tr>
<td>Desired speed</td>
<td>115</td>
<td>125</td>
<td>120</td>
<td>110-120</td>
<td>110-120</td>
<td>120</td>
<td>120</td>
<td>110</td>
<td>120</td>
<td>120</td>
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</table>
Analyze method

• Comparing specified and achieved relative speed and position
• Mean free speed analyses
• Questionnaire
• Interviews
### Participant’s mean free speed

<table>
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</thead>
<tbody>
<tr>
<td>Controlled – Warm up</td>
<td>1.22</td>
<td>0.91</td>
<td>2.11</td>
<td>1.64</td>
<td>0.44</td>
<td>0.85</td>
<td>-0.04</td>
<td>0.04</td>
<td>0.09</td>
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<tr>
<td>Controlled – Autonomous 1</td>
<td>0.80</td>
<td>0.99</td>
<td>2.70</td>
<td>1.66</td>
<td>1.52</td>
<td>1.18</td>
<td>0.84</td>
<td>0.06</td>
<td>0.16</td>
<td>0.27</td>
</tr>
<tr>
<td>Controlled – Autonomous 2</td>
<td>1.76</td>
<td>1.48</td>
<td>4.28</td>
<td>1.76</td>
<td>1.36</td>
<td>1.00</td>
<td>2.93</td>
<td>0.05</td>
<td>-0.32</td>
<td>0.61</td>
</tr>
<tr>
<td>Controlled – Autonomous 3</td>
<td>1.39</td>
<td>1.72</td>
<td>4.64</td>
<td>2.01</td>
<td>1.24</td>
<td>1.20</td>
<td>0.34</td>
<td>0.40</td>
<td>-0.19</td>
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</table>

The participants drive faster during controlled everyday life traffic!
• No observed conspicuous actions in connection with plays
• Overtaking situations during controlled everyday life traffic was not normal
• The autonomous traffic is driving slow
Conclusions

- Casting and transportation of active roles works satisfactory.
- Casting and transportation of no-roles do not always work as intended.
- Type of controlled everyday life traffic matters!
- Autonomous everyday life traffic observed as slower than real freeway traffic.
Future research

- Tests in more dense traffic
- Test in “real” driving simulator experiment
- Algorithm development for other road types (two-lane highways, urban, etc)