Effects of Authority Transitions between Adaptive Cruise Control and Manual Driving on Traffic Flow Efficiency.

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Introduction

Road transport

Congestion  Accidents  Pollution

Adaptive Cruise Control (ACC)

What are the effects of authority transitions?

Traffic flow efficiency
1. Overview of work

- Authority transitions
- Driving Behaviour
  - Microscopic traffic flow simulation
  - Analysis of empirical driving behaviour
    - Analysis of traffic flow characteristics
    - Conclusion and future research
2. Literature review

Data collection methods

- FOT
- Driving simulator

Motivations for authority transitions

- Behavioural adaptations of drivers

Car following and lane-changing models

- Effects on traffic flow efficiency
2.1. Motivations for authority transitions

Authority transitions between ACC and manual driving

<table>
<thead>
<tr>
<th>Discretionary</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers switches off</td>
<td>System switches off</td>
</tr>
<tr>
<td>Lane change</td>
<td>Sensor failure</td>
</tr>
<tr>
<td>Create a gap</td>
<td>Constraints reached</td>
</tr>
<tr>
<td>Left-lane speed</td>
<td></td>
</tr>
<tr>
<td>adaptation</td>
<td></td>
</tr>
</tbody>
</table>
2.2. Behavioural adaptations of drivers

**Behavioural aspects that are influenced by ACC**

| Higher speeds | Shorter time headways |

**Changed role of the driver**

| Reduction of vigilance | Reduction of situation awareness |

**Ability to respond to emergency situations**
2.3. Microscopic traffic flow models

- Car following models
- Lane-changing models

ACC are a different type of vehicle
Authority transitions are not possible

ACC vehicles have an effect of traffic flow (Kesting 2008; Klunder, et al. 2009)

- Capacity
- Capacity drop
- Stability
3. Methodology

Microscopic traffic flow simulation

Manual driver

Transitions

ACC

Control condition

No transitions

Experimental condition

Drivers can switch off

Lane changing manoeuvre

Switch off ACC

Do not switch off ACC
3.1. Model specification

Car following models

IDM

Transitions

ACC model

Treiber, et al. 2000


Inter-driver heterogeneity

\[ a_{max_n} \sim \text{truncN}(1.4, 0.3) \]

\[ b_{max_n} \sim \text{truncN}(2, 0.3) \]

\[ T_n \sim \text{truncN}(1.5, 0.3) \]
# 3.1. Model specification

## Lane changing model

<table>
<thead>
<tr>
<th>Safe gap criterion</th>
<th>Incentive criterion right to left</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ds_{ego_n} &gt; gap_{ego_n}$</td>
<td>$V_{hp_l} &gt; V_l + \epsilon_n$</td>
</tr>
</tbody>
</table>

$gap_{ego_n} = s_0 + \theta_n \cdot T_n \cdot v_n$

$ds_{hp\_f_n} > gap_{hp\_f_n}$

$gap_{hp\_f_n} = s_0 + \theta_n \cdot T_f \cdot v_f$

$\theta_n \sim truncN(1, 0.1)$  
$T_n \sim truncN(1.5, 0.3)$

$\epsilon_n \sim truncN(1, 0.5)$
4. Simulation results

<table>
<thead>
<tr>
<th>Design</th>
<th>Two lane highway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand levels</td>
<td>1500 - 4000 veh/h</td>
</tr>
<tr>
<td>Mixture</td>
<td>0% ACC</td>
</tr>
</tbody>
</table>

Analysis of traffic flow characteristics

<table>
<thead>
<tr>
<th>Time &amp; Distance headways</th>
<th>Speed</th>
<th>Acceleration</th>
<th>Density</th>
<th>Traffic flow</th>
</tr>
</thead>
</table>

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4.1. Time headway
4.1. Time headway

4.2. Distance headway
4.3. Speed

4.4. Acceleration
4.5. Density

4.6. Flow
5. Driving simulator experiment

Authority transitions between ACC and manual driving

Control condition | Experiment 1 | Experiment 2
--- | --- | ---
Manual driving | Mandatory | Discretionary
System switches off | Vehicle slows down | Driver switches off
Manual driving | | Manual driving
Driver switches on | Driver switches on |
5.1. Experimental results
6. Conclusion and future research

Authority transitions influence traffic flow efficiency
- Current models are not adequate

Validity of decision rule introduced
- Parameter calibration

When do drivers disengage ACC?
- Human factors
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