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

<table>
<thead>
<tr>
<th>Authority transitions between ACC and manual driving</th>
<th>Discretionary</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers switches off</td>
<td>Lane change</td>
<td>System switches off</td>
</tr>
<tr>
<td></td>
<td>Create a gap</td>
<td>Sensor failure</td>
</tr>
<tr>
<td></td>
<td>Left-lane speed adaptation</td>
<td>Constraints reached</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
Treiber, et al. 2000

Transitions

ACC model

Inter-driver heterogeneity

\[ a_{\text{max}}_n \sim \text{truncN}(1.4, 0.3) \]
\[ b_{\text{max}}_n \sim \text{truncN}(2, 0.3) \]
\[ T_n \sim \text{truncN}(1.5, 0.3) \]
3.1. Model specification

<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>
<tr>
<td>$gap_{ego_n} = s_0 + \theta_n \cdot T_n \cdot v_n$</td>
<td></td>
</tr>
<tr>
<td>$ds_{hp_f_n} &gt; gap_{hp_f_n}$</td>
<td></td>
</tr>
<tr>
<td>$gap_{hp_f_n} = s_0 + \theta_n \cdot T_f \cdot v_f$</td>
<td></td>
</tr>
<tr>
<td>$\theta_n \sim truncN(1, 0.1)$</td>
<td>$\epsilon_n \sim truncN(1, 0.5)$</td>
</tr>
<tr>
<td>$T_n \sim truncN(1.5, 0.3)$</td>
<td></td>
</tr>
</tbody>
</table>
## 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>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic flow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Control condition</th>
<th>Experiment 1</th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual driving</td>
<td>Mandatory</td>
<td>Discretionary</td>
</tr>
<tr>
<td>System switches off</td>
<td>Vehicle slows down</td>
<td>Driver switches off</td>
</tr>
<tr>
<td>Manual driving</td>
<td>Driver switches on</td>
<td>Manual driving</td>
</tr>
<tr>
<td></td>
<td>Driver switches on</td>
<td>Driver switches on</td>
</tr>
</tbody>
</table>
5.1. Experimental results

![Graphs showing experimental results with various metrics over distance.](image-url)
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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