Key variables merging behaviour

Empirical comparison between two sites and assessment of gap acceptance theory

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Introduction

Background

• Driver behaviour at merging sections is cause of breakdowns
• Interaction between flow on main motorway and flow on acceleration lane
• Merging process part of many models
  • Gap acceptance models
  • No validation due to lack of microscopic empirical data

• Research aim
  • Improve insights into merging behaviour
  • Assess and extend existing merging models
Introduction

Definitions
Introduction
Definitions

Accepted gap

Rejected gap

Traffic direction

Lag gap  Veh. length  Lead gap

Veh. length

Acceleration lane
Introduction

Conceptual model

- Cooperative lane change
- Courtesy yielding

Traffic conditions
- main road

Road configuration
- (length acceleration lane)

Offered gaps

Decision to merge

- Speed putative follower, speed putative leader, acceleration putative follower, acceleration putative leader
- Merger characteristics
  - (current position, current speed, vehicle type, aggressiveness)

Accepted gap
- Merge location
- Merge speed

Rejected gap(s)
Research approach

• Empirical data analyses
  • Using microscopic trajectory data
  • On two sites
  • Finding statistical relations between merging characteristics
• Assessing principles of gap acceptance model
  • Based on trajectory data
• Developing new model
  • Based on logistic regression
  • Assess model quality for both sites
Empirical data collection

Two sites

Bodegraven, the Netherlands

Grenoble, France (mocopo.ifsttar.fr)
Data analyses

Merging characteristics

Cooperative lane change

Traffic conditions
- main road

Road configuration
- length acceleration lane

Offered gaps

Decision to merge

Accepted gap
- Merge speed

Rejected gap(s)

Compatibility yielding

Speed putative follower, speed putative leader, acceleration putative follower, acceleration putative leader

Merger characteristics
- current position, current speed, vehicle type, aggressiveness
Data analyses

Data characteristics

- Congested traffic (speeds < 20 m/s)
- Dry weather
- Only passenger cars in Grenoble, thus no vehicle type studied

<table>
<thead>
<tr>
<th></th>
<th>Number of accepted gaps</th>
<th>Number of rejected gaps</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bodegraven</strong></td>
<td>377</td>
<td>100</td>
<td>477</td>
</tr>
<tr>
<td><strong>Grenoble</strong></td>
<td>242</td>
<td>117</td>
<td>359</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>619</td>
<td>217</td>
<td>836</td>
</tr>
</tbody>
</table>
Data analyses

Descriptive statistics

- Accepted gap [m]
- Rejected gap [m]
- Merging position
- Merging speed [m/s]
Data analyses

Relation between accepted gap and merge speed

![Graph showing the relation between accepted gap and merge speed for Bodegraven and Grenoble.](image)
Assessing gap acceptance

Background

• If a gap is larger than a critical gap, it is accepted
• Otherwise, it is rejected

• According to literature, the critical gap may depend on
  • Speed of merging vehicle
  • Acceleration of putative following vehicle
  • Remaining distance on acceleration lane
  • …

\[ G_{nt}^{ilag} = \exp \left( \gamma_{ilag} + \frac{0.439}{1 + \exp \left( 0.0242 + 0.00018\nu_n \right)} d_{nt} + 0.208 \max \left( 0, \Delta V_{nt}^{lag} \right) \right) 
+ 0.184 \min \left( 0, \Delta V_{nt}^{lag} \right) 
+ 0.0545 \max \left( 0, \alpha_{nt}^{lag} \right) + \alpha_{nt}^{lag} \nu_n + \varepsilon_{nt}^{ilag} \]

From Choudhury et al. (2007)
Assessing gap acceptance

Using critical gap thresholds by Choudhury et al. (2007)

Bodegraven

Grenoble

Accepted gap
Rejected gap
Aggressive
Timid
New merging model

Introduction

- Principal Component Analysis applied
- Most contributing variables
  - position on acceleration lane
  - offered gap (length in meters)
  - speed difference between putative leader and putative follower
  - speed difference between merging vehicle and putative follower
- Generalised linear model
  - To quantify influencing factors on probability whether drivers accept or reject a certain gap
- Explanatory variables are normalized to establish a comparison
- Use logit function to quantify
New merging model

All factors included

\[ \ln \frac{p(1|X)}{1 - p(1|X)} = \beta_0 + \beta_x X_{\text{pos}} + \beta_{\text{gap}} X_{\text{gap}} + \beta_{\Delta V_{PL-PF}} X_{\Delta V_{PL-PF}} + \beta_{\Delta V_{MV-PF}} X_{\Delta V_{MV-PF}} \]
New merging model

Without position of gap on acceleration lane

\[
\ln \frac{p(1|X)}{1 - p(1|X)} = \beta_0 + \beta_{\text{gap}}X_{\text{gap}} + \beta_{\Delta V_{\text{PL-PF}}}X_{\Delta V_{\text{PL-PF}}} + \beta_{\Delta V_{\text{MV-PF}}}X_{\Delta V_{\text{MV-PF}}}
\]
New merging model

Without speed difference between putative leader and follower

\[
\ln \frac{p(1|X)}{1 - p(1|X)} = \beta_0 + \beta_x X_{pos} + \beta_{gap} X_{gap} + \beta_{\Delta V_{MV-PF}} X_{\Delta V_{MV-PF}}
\]
Conclusions and future research

- Comparative analysis of merging behaviour on motorways
- Differences at two locations
  - Different geometric configuration
  - Different traffic conditions (more severe congestion in Grenoble)
- Assessment of gap acceptance model
  - No boundary similar to critical gap could be found
- Proposal of new stochastic model
  - Statistically significant set of variables
  - Logistic regression analysis with strong predictive power

- Future research
  - Study other locations
  - Validate model in other situations