Driving behaviour transition during evacuation and its impact on traffic flow operations based on an open-source platform "OTSim"

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• OTSim platform and the driving models
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Introduction

Control vs. Evacuees’ behaviour
• Pre-trip choice & On-trip routing and driving

Normal situation vs. Emergence/evacuation situation
• $a \uparrow$, $b \uparrow$, $v_{\text{free}} \uparrow$, $T_{\text{min}} \downarrow$.

Driving behaviour transition during evacuation?
• Traffic flow, road capacity, travel time, performance...

Heterogeneous behaviour at evacuation transition phase vs. traffic flow operations

Various traffic simulation models (different scale and modal)
Methodology

An open-source traffic simulation platform

Why Open Traffic Simulator (OTSim)?

Why a new transport model environment?
Why a new transport model environment?

*Given the current supply of traffic models*

**Supply of model packages:** a great variety in commercial models, offering a lot of methods, approaches and tastes

**User groups:** consultants, public authorities, road management organizations, automotive-, ICT/ITS industry, service providers and researchers

**Problem:** current packages not always offer the desired workflow and flexibility for academic research
Current (academic) research practice

**Code the Transport Model from scratch**

👍 ...  

Tailored to the needs  
Learn by experience

🙁 ... but  

Large development costs  
Only small part of the code is “new”  
No attention for software quality: re-use of the code is rare
OTSim
— An open-source toolbox for transport & traffic research

Open-source Multi-scale Multi-modal

http://opentrafficsim.org

Implementation of a wide range of traffic simulation models:
- From microscopic, macroscopic to meta-level
- From motorized vehicles (FASTLANE, FOSIM, MOTUS), track-bounded modes (trams, trains, buses [Busmezzo], BRT, etc.) to pedestrian flows (Nomad).
Middleware of OTSim

*Interfaces of network, model, visualization..... And utilities*

- Input data
  - Traffic infrastructure
  - Generation of traffic demand

- Graphical Edit/view
  - Network objects

- Output
  - Generating output data
    - (q/k/v contour plots, trajectory plot, log file for vehicle generation and destruction)
Micro-level: *MOTUS* simulation
Micro-level: *MOTUS* simulation

**IDM model (extension):**

\[
\frac{dv}{dt} = a \cdot \min \left( 1 - \left( \frac{v}{v_0} \right)^\delta, 1 - \left( \frac{s}{s^*} \right)^2 \right)
\]

\[
s^* = s_0 + v \cdot T_{\text{min}} + \frac{v \cdot \Delta v}{2 \sqrt{a \cdot b}}
\]

**LMSR model:** 3 desire to follow a route \((d_r)\), to gain speed \((d_s)\), and to keep right \((d_b)\)

\[
d^{ij} = d^{ij}_r + \theta^{ij}_v \cdot (d^{ij}_s + d^{ij}_b)
\]
Transition variable definition

Activation level (A): driving behaviour (gradually or suddenly) transforms from “normal” to “emergencies” [0, 1]

Transition time (T): time to reach full/targeted activation level

Penetration rate (P): share of activated drivers in the total population [0, 100%]
Travel behaviour choice

- Short/no notice evacuation strategy (one super-destination)
- Predefined route sets
- Shortest path algorithm (link-penalty-based route choice, logit model)
Experiment setup

• Sensitivity analysis regarding transition variables

• Implication for traffic management and control

Demand profile

Delft road network in the OTSim interface
# Experiment setup

Relative change of selected driving parameters during transition

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Calibrated value in MOTUS</th>
<th>Normal</th>
<th>Emergency</th>
<th>Relative Change (RC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$ (m/s²)</td>
<td>1.25*</td>
<td>0.94*</td>
<td>1.46</td>
<td>0.55</td>
</tr>
<tr>
<td>$a_{urban}$ (m/s²)</td>
<td>2.0</td>
<td>0.94</td>
<td>1.46</td>
<td>0.55</td>
</tr>
<tr>
<td>$b$ (m/s²)</td>
<td>2.09</td>
<td>0.87</td>
<td>0.97</td>
<td>0.11</td>
</tr>
<tr>
<td>$b_{urban}$ (m/s²)</td>
<td>3.5</td>
<td>0.87</td>
<td>0.97</td>
<td>0.11</td>
</tr>
<tr>
<td>$v_0$ (km/h)</td>
<td>123.7</td>
<td>108</td>
<td>127</td>
<td>0.18</td>
</tr>
<tr>
<td>$T_{min}$ (s)</td>
<td>0.56</td>
<td>0.78</td>
<td>0.25</td>
<td>-0.68</td>
</tr>
</tbody>
</table>

*: The values in [5], however, pertain to mixed traffic. Cars as in MOTUS start somewhat higher.
Experiment setup

Simulation scenarios
with different testing levels of transition variables

<table>
<thead>
<tr>
<th>T (s)</th>
<th>A</th>
<th>P (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Testing levels</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>600</td>
<td>0.33</td>
<td>33</td>
</tr>
<tr>
<td>1800</td>
<td>0.66</td>
<td>66</td>
</tr>
<tr>
<td>3600</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>7200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Several simulation runs with different random seeds to count for the effect of variability.
## Result discussion

<table>
<thead>
<tr>
<th>Sce. Var. ActL/P</th>
<th>Ave. TT(s)</th>
<th>Clearance time (s) 100%</th>
<th>OD pair TT (normal drivers) mean (s) std.</th>
<th>OD pair TT (activated drivers) mean (s) std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref.</td>
<td>288.52</td>
<td>19380</td>
<td>259.06 93.47</td>
<td>- -</td>
</tr>
<tr>
<td>1 0.33/33%</td>
<td>267.06</td>
<td>19050</td>
<td>195.15 38.66</td>
<td>191.26 37.28</td>
</tr>
<tr>
<td>2 0.33/66%</td>
<td>231.88</td>
<td>18870</td>
<td>190.23 34.97</td>
<td>187.96 35.41</td>
</tr>
<tr>
<td>3 0.33/100%</td>
<td>196.96</td>
<td>18870</td>
<td>- -</td>
<td>176.38 26.52</td>
</tr>
<tr>
<td>4 0.66/33%</td>
<td>251.43</td>
<td>19110</td>
<td>193.99 40.31</td>
<td>188.39 40.40</td>
</tr>
<tr>
<td>5 0.66/66%</td>
<td>196.41</td>
<td>18870</td>
<td>182.76 30.32</td>
<td>176.23 26.93</td>
</tr>
<tr>
<td>6 0.66/100%</td>
<td>185.37</td>
<td>18870</td>
<td>- -</td>
<td>166.73 23.93</td>
</tr>
<tr>
<td>7 1.0/33%</td>
<td>248.86</td>
<td>19020</td>
<td>198.88 46.62</td>
<td>193.81 45.20</td>
</tr>
<tr>
<td>8 1.0/66%</td>
<td>192.35</td>
<td>18870</td>
<td>179.25 26.91</td>
<td>171.76 25.36</td>
</tr>
<tr>
<td>9 1.0/100%</td>
<td>181.87</td>
<td>18870</td>
<td>- -</td>
<td>160.76 20.82</td>
</tr>
</tbody>
</table>
Result discussion
Result discussion

- Driving behaviour influencing factors
  - Evacuation time
  - Penetration of aggressive drivers
  - Evacuation information, etc.

- Traffic control via information dissemination
  - VMS,
  - in-car devices,
  - speed-limit control
Conclusion and future research

1. Driving behaviour transition successfully modelled in OTSim
2. Three transition variables: activation level, activated driver penetration, and transition time.
3. Improving performance with $A^\uparrow$, $P^\uparrow$, $T^\downarrow$.

- Traffic control: information dissemination with VMS, in-car devices, speed-limit control
- Only explicitly adjust longitudinal driving parameters (acceleration, deceleration, free-flow speed, desired time headway)
- Investigation of lane change behaviour under evacuation
- Validate the control concept
Thank for your attention!

Questions?

Remarks?

Want to know more or provide feedback?
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