Using GOMS and the Thinking Aloud Technique to infer driver states

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Background: The Nature of Driving

Driving is
1. a **satisficing** task,
2. partially self-paced

**satisfying** + **suffice**

Background: The Nature of Driving

Driving is
1. a "satisficing" task,
2. partially self-paced,
3. in a physical, dynamic environment,
4. largely unregulated,
5. where you can die if you make certain mistakes.

Gibson & Crooks (1938): A theoretical field analysis of automobile driving.
Driver states: Two Definitions

1. latent variable, "impairment level"
   - fatigue
   - drowsiness
   - (in)attention / distraction

   e.g. Regan, Hallett, & Gordon (2011): Driver distraction and driver inattention

2. "state" as in "state diagram", usually on the tactical level
   - overtaking
   - lane change
   - lane following
   - car following

   e.g. Cacciabue & Carsten (2011): A simple model of driver behaviour.
Problem: Is that really what is happening?

Chovan (1994). Examination of lane change crashes and potential IVHS countermeasures.
Problem: Slicing the World into Discrete States

States in the Railway system

States in the Aviation
Goals
- state of affairs to be achieved
- determine possible methods

Operators
- cognitive, perceptual, motor acts
- physical or mental
- change state of user, environment

Methods
- procedure to accomplish goals
- consist of operators

Selection Rules
- Which method to use?

Solution: Task Analysis, e.g. GOMS

The Model Human Driver
Going Bottom-Down: A GOMS for Driving

cognition

goals

information
glances

uptake
driving data

physical level

touch
### Data Fusion

#### Chart 10

<table>
<thead>
<tr>
<th>t</th>
<th>touch data</th>
<th>vehicle data</th>
<th>gaze</th>
<th>goals</th>
<th>cognitive operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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The Driving Simulator

DLR's Virtual Reality Lab
- 360° projection
- mock-ups or real car
Scenario 1 - Controlled

"Stay between 120 and 130 km/h"
Scenario 2 - Realistic

"Drive 110 - 150 km/h"
Subjects

- Box plot for age with N=9
- Bar chart for highest educational degree by gender (female and male)
- Scatter plot for frequency of driving with sex (female and male)

Since when do you have your driver's license?

How frequently did you drive during the last year?
Data Recording

thinking aloud: Webcam

eye tracking: Smart Eye Pro

driving & simulation data
• velocity, acceleration
• positions
• steering (wheel) angle
• pedal input

pressure sensors
Data Recording
The Time Course of the Lane Changes
Overall Goals
More Specific Goals
## Cognitive Operators

<table>
<thead>
<tr>
<th>category</th>
<th>sub category</th>
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</thead>
<tbody>
<tr>
<td>anticipating</td>
<td>vehicles in same lane will change speed</td>
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<tr>
<td></td>
<td>vehicles in other lane will change speed</td>
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<td>lead vehicles will change lanes</td>
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<td>flow of traffic will change</td>
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<tr>
<td>evaluations</td>
<td>gap size</td>
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<td></td>
<td>distances to other vehicles, especially lead car</td>
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<tr>
<td></td>
<td>accelerations of other vehicles</td>
</tr>
<tr>
<td></td>
<td>situation (&quot;nothing is happening&quot;)</td>
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</tbody>
</table>
## Cognitive Operators

<table>
<thead>
<tr>
<th>Category</th>
<th>Sub Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information retrieval</td>
<td>from LTM (traffic rules)</td>
</tr>
<tr>
<td></td>
<td>from WM (&quot;there is still a car back there&quot;)</td>
</tr>
</tbody>
</table>
Summary

What about driver states?
• useful to structure the task:
  1. information gathering
  2. decision making
  3. execution
• but no good fit with "what actually happens"

Problems with discrete states
• "It's the situation, stupid".
• *information gathering* and (a little less) *decision making* are what we do all the time. **That is the task.**
• states do not cover anticipation well
Summary + Outlook

Satisficing
• much of driving is "don't do X"
• does not clearly indicate what should be done

What's next?
• Sketch alternatives for a given situation.
• From the data: Why was that alternative chosen, not the others?
Thank you for your attention!