Retrieving human control after situations of automated driving

How to measure Situation Awareness
Transitions to retrieve (human) control might regularly occur. Many scenarios: Cut-in, targeted vehicle merges out, $v_{av}$ oscillates around 60km/h, road work, etc.

What interface does support the transitions in those situations?
Background

- During automation, the driver is not actively involved in the control-loop causing problems to take over control.
- Eventually an interface should be optimized to support drivers in taking over control as successful as possible.
  - A prerequisite for successful take over is Situation Awareness (SA)
  - SA = level of a person’s awareness of a situation, and how his actions will impact how the situation develops
    1. the observed presence or absence of elements in the situation;
    2. the participants’ comprehension of the meaning of these elements;
    3. anticipated future state of the elements

- Within a design process the influence an interface type has on the extent and time in which SA is gained, should be assessed.
- To assess this influence of interface type on SA, it should first be evaluated what method for measuring SA is most suitable.
  - Focus within this research: developing an assessment frame-work
Situation Awareness Measurement methods

**Freeze probe techniques**
- Queries relate to probes within a simulation which is temporarily being ‘freezed’
- SAGAT (Endsley) is most commonly used.

**Real-time probe techniques**
- Expert administers probes real-time
- Typical application is for non time-critical supervisory tasks

**Self-rating techniques**
- A subjective rating of SA:
  - most common: SART

**Performance measures**
- Indirect measure: e.g. lane position or TTC
Methods for measuring Situation Awareness

SART: Situation Awareness Rating Technique
● A subjective rating of SA representing the 3 levels of SA
● Using a rating scale with 10 dimensions
● Filled out by the participants (ambiguous whether their judgement is ‘correct’)
● Appears to be most commonly used

SAGAT (Situation Awareness Global Assessment Technique)
● Question construction is tailored per experiment (no standardized questionnaire)
● For each task, SAGAT questions must be developed to fully probe the situation awareness construct on all three levels.
● SAGAT requires tests in which tasks are being ‘freezed’
● The number of questions presented during each freeze should be kept small to minimize interference effects in working memory.
● Examples of questions: What type of car was behind (car, truck, van)?; What was the particular colour of neighbouring vehicle?; What was the reason for take-over?; etc.
Apparatus / Simulator environment

Driving simulator with simulated motorway. Below right: secondary task

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Criticality conditions (available time for take-over)

\[ t=0 \]

\[ \begin{align*}
\text{aiCar} \quad X \\
\text{aiCar} \quad Y \\
\text{aiCar} \quad Z
\end{align*} \]

\[ v=16\text{m/s} \]

\[ \text{Time headway} = 1\text{s} \]

\[ (16\text{ meter}) \]

\[ t=x \] (Target vehicle starts emergency brake)

\[ \begin{align*}
\text{aiCar} \quad Y \\
\text{aiCar} \quad Z \\
\text{sim}
\end{align*} \]

\[ a= -8\text{m/s}^2 \]

\[ (v=16\text{m/s}, \text{as long as driver does not intervene}) \]

Without intervention in 2.20s an accident will occur (for this example)

<table>
<thead>
<tr>
<th>Time headway</th>
<th>0:50s</th>
<th>1:00s</th>
<th>1:50s</th>
<th>No emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without intervention, accident within…</td>
<td>1:50s</td>
<td>2:20s</td>
<td>2:80s</td>
<td></td>
</tr>
<tr>
<td>Driving on left lane</td>
<td></td>
<td></td>
<td></td>
<td>Conditions in random order for each participant</td>
</tr>
<tr>
<td>Driving on right lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Successfulness vs. criticality (available time) of take-over

- Positive correlation between successfulness and criticality ($r = 0.541$, $p<0.001$)
- Unsuccessful take-over (“Accident”) occurs most often during the most critical time condition (0,5s); the least critical condition has the highest success-rates.
- Even the highest critical situations were manageable to some degree.
- Chosen levels of criticality influenced driving performance; although criticality was high in all conditions.
Situation awareness vs. criticality of take-over

- Criticality correlates with SA-SART ($r = 0.284, p = 0.004$)
- No significant correlation between Criticality and SA-SAGAT ($r = -0.169, p = 0.089$).

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“least time” << Time-conditions (s) >> “most time”
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- SART correlates with criticality as was expected
  - Participants in the less critical conditions were better able to divide their attention between observing the traffic and controlling their own vehicle.
- Insignificant negative correlation between SAGAT and criticality, contrary to expectations
Situation awareness vs. successfulness of take-over

- SA-SART is positively correlated with success-rate
  \( r = 0.323, p = 0.002 \)
- SA-SAGAT shows no correlation with success-rate
  \( r = 0.020, p = 0.852 \)

- **SART scores confirm assumption when SA increases, so does the chance for a successful take-over.**
Suitability of methods for measuring situation awareness

- Contrary to expectations the objective SAGAT-method showed no correlation with available time, nor to success rate, for taking over control.
  - At least one of the measures is providing a false level of SA
  - The SART questionnaire has shown some promising results for use in the current set-up, and according to expectations

- Based on the weak and negative correlation between Criticality and SA-SAGAT, we presume that the moment of probe-taking—and probably the probes themselves—have influenced SAGAT-scores.
  - Possible explanation: Within the least critical time condition, the traffic is more changeable probably resulting in ambiguity where the probes referred to. Hence, more wrong SAGAT-answers
Main conclusion & future work

- Using SART for measuring SA within time-critical situations of taking over control is at least a secure consideration

- Continue to also consider SAGAT
  - Objectiveness of measurement method remains valuable reason
  - Improve how SAGAT is been applied
    - Especially moment of probe-taking
    - First attempts are promising

Recommendation:
- Improve diversity in situations which require take-over to avoid habituation
Thank you for your attention

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