State of the art on measuring driver state and technology-based risk prevention and mitigation

Findings from the i-DREAMS project

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Outline

• The i-DREAMS Project
• Literature Review Methodology
• Significant findings
• Next steps
The i-DREAMS project (1)

13 Project partners:

National Technical University of Athens
Universiteit Hasselt, Loughborough University, Technische Universität München, Kuratorium für Verkehrssicherheit, Delft University of Technology, University of Maribor, OSeven Telematics, DriveSimSolutions, CardioID Technologies, European Transport Safety Council, POLIS Network, Barraqueiro Transportes S.A.

Duration of the project:

36 months (May 2019 – May 2022)
The i-DREAMS project (2)

Definition, development, testing and validation of a context-aware ‘Safety Tolerance Zone’ for driving
Measurements considered in i-DREAMS
Literature Review

Systematic Literature Review

- Identification of terms
- Title & Abstract screening
- Focus on underlying constructs (e.g. emotions, distraction types), indicators, technical equipment, results and conclusions

<table>
<thead>
<tr>
<th>Factor</th>
<th>Key words (without word stem variations)</th>
<th>Screened papers</th>
<th>Included papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Demand</td>
<td>“task demand” AND “driving measures” OR “performance measurements” OR “driver characteristics” OR “driving monitoring” OR “workload” OR “traffic conditions” OR “traffic” OR “weather” OR “road layout” OR “time of day”</td>
<td>413</td>
<td>11</td>
</tr>
<tr>
<td>Distraction</td>
<td>“distraction” OR “distracted” OR “inattention” OR “inattentive” AND “driver monitoring” OR “driver measure”</td>
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<td>Emotions</td>
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<td>38</td>
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<tr>
<td>Fatigue and sleepiness</td>
<td>“fatigue” OR “sleep” OR “drowsy” OR “alert” OR “monotonous” OR “tired” OR “bored” OR “weariness” OR “time on task” AND “driver monitoring” OR “physiological measure” OR “blink” OR “perclos” OR “yawning” OR “eye movement” AND “drive” OR “car” OR “professional driver” OR “commercial driver” OR “traffic” OR “road safety”</td>
<td>1,545</td>
<td>187</td>
</tr>
</tbody>
</table>
Task Demand

- Task demand as result of exogenous factors
  - Road
  - Traffic environment
  - Weather
  - Time of day

- Task demand as cognitive workload

<table>
<thead>
<tr>
<th>Road layout</th>
<th>Traffic environment</th>
<th>Weather</th>
<th>Time of day</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High number of lanes</td>
<td>• Annual average daily traffic</td>
<td>• Rain</td>
<td>• Darkness</td>
</tr>
<tr>
<td>• Narrow lanes</td>
<td>• Through traffic per lane</td>
<td>• Sun</td>
<td>• Twilight</td>
</tr>
<tr>
<td>• Wider lanes with high traffic volume</td>
<td>• Congestion</td>
<td>• Wind</td>
<td>• Peak hours</td>
</tr>
<tr>
<td>• Length of deceleration lane</td>
<td></td>
<td>• Frost</td>
<td></td>
</tr>
<tr>
<td>• Roundabouts</td>
<td></td>
<td>• Snow</td>
<td></td>
</tr>
<tr>
<td>• Highway curves</td>
<td>Train drivers</td>
<td>• Fog</td>
<td></td>
</tr>
<tr>
<td>• Geometric design</td>
<td>• Track changes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Monotony of environment</td>
<td></td>
<td>Train drivers</td>
</tr>
<tr>
<td></td>
<td>• Behaviour of passengers</td>
<td></td>
<td>• Obstruction due to weather condition</td>
</tr>
<tr>
<td></td>
<td>• Obstruction of tracks</td>
<td></td>
<td>• darkness</td>
</tr>
</tbody>
</table>

Table 1: Exogenous factors affecting task demand
Task Demand - Cognitive load

- Studies mainly on road layout, traffic condition, weather
- Rarely on time of day
- Measured most frequently by physiological indicators, e.g. ECG
- Other indicators measured through
  - EEG
  - Vehicle kinematics
  - Skin conductance
  - Occular indicators

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change</th>
<th>Conditions/Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed variation</td>
<td>↑</td>
<td>Increase in HGV composition, shorter time headway</td>
</tr>
<tr>
<td>Acceleration signatures</td>
<td>↑</td>
<td>Changes in road type</td>
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<tr>
<td>Blink rate</td>
<td>↓</td>
<td>Sharper road curves</td>
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<tr>
<td>Horizontal spread</td>
<td>↑</td>
<td>Changes in road type</td>
</tr>
<tr>
<td>SCR</td>
<td>↑</td>
<td>Higher visibility conditions, changes in road type</td>
</tr>
<tr>
<td>Heart rate</td>
<td>↓</td>
<td>Dense traffic, adverse weather (fog), transition highway to urban traffic</td>
</tr>
<tr>
<td>Oxygenated haemoglobin</td>
<td>↑</td>
<td>Changes in road type</td>
</tr>
<tr>
<td>Heart rate</td>
<td>↑</td>
<td>Lange changing events, transition motorway to urban traffic</td>
</tr>
</tbody>
</table>
Task demand findings

• Mainly simulator experiments
• No thresholds provided
• Most reliable indicators (work load)
  • Cardiac measures (heart rate, heart rate variability)
  • Duration of fixations
Attention and Distraction

• Most studies on visual distraction
• Main method used: eye-tracking
• Very heterogenous study designs and equipment > excacerbates comparison
• No thresholds for driver behaviour indicators
• No mode-specific measurement methods
Mental State

- More studies on sleepiness than fatigue and in simulators
- Most in-built commercial systems use ocular measures (PERCLOS and Blink Duration)
- Source of reduced attention and distractability needs to be defined for interventions
- Consideration of professional vs. non-professional drivers
- Mental state’, ‘emotions’, etc. are theoretical constructs that need a decisive definition.
Conclusions & recommendations

• Most of the evidence is available for car drivers.
• ‘Using at least two approaches for driver state monitoring is beneficial for validity and reliability
• Cameras, eye tracking, and heart rate sensors should be considered
• Drivers’ traits and characteristics should be explored.
• Thoroughly testing indicators and measures at the simulator stage is indispensable
State of the art on measuring driver state and technology-based risk prevention and mitigation
Findings from the i-DREAMS project

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