Automated vehicles in mixed traffic environments – the value of external HMI

Anna Schieben
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AUTOMATED VEHICLES
## Deployment of automated vehicles

<table>
<thead>
<tr>
<th>Automation Level</th>
<th>Established</th>
<th>2018</th>
<th>2020</th>
<th>2022</th>
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<td>Urban and Sub-Urban Pilot</td>
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<td>Highway Autopilot including Highway Convoy</td>
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<td>Conditional Automation</td>
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<td>Partial Automation</td>
<td>Traffic Jam Chauffeur</td>
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<td>Traffic Jam Assist</td>
<td>Parking Assist</td>
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<td>Driver Assistance</td>
<td>Adaptive Cruise Control</td>
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<td>Stop &amp;Go</td>
<td>Lane Keeping Assist</td>
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<td>Lane Change Assist</td>
<td>Parking Assist</td>
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<td>Level 0:</td>
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<td>No Driving Automation, support beyond human capability to act</td>
<td>Lane Departure Warning</td>
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<td>Blind-spot Warning</td>
<td>Forward Collision Warning</td>
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<td>ABS, ESC</td>
<td>Emergency Brake</td>
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**Fully Automated Passenger Cars**

*ERTRAC Roadmap (2017)*
Automated vehicles in mixed traffic

Source: Lagström & Lundgren (2015) AVIP Project
Integrating automated vehicles in mixed traffic

**Situation Today**

- On-board driver
- Other traffic participants

**Future situation: Automated vehicles in mixed traffic environments**

- On-board user
- Other traffic participants

**Vehicle automation**
The interACT project

interACT – Designing cooperative interaction of automated vehicles with other road users in mixed traffic environments

Programme: EU/H2020-ART04 - Safety and end-user road automation in the transition period
Period: May 2017 – April 2020
EU Funding: 5.527.581 €
Coordinator: Anna Schieben, DLR e.V.
Partners: 8 industrial and academic partners from 4 European countries (Germany, Italy, Greece, UK)
EU twinning project: AVIntent (NHTSA)

www.interact-roadautomation.eu
The challenge

Achieve a safe, highly accepted and efficient integration of Automated Vehicles in mixed traffic environment

1st Enabler
Psychological models

2nd Enabler
Intention recognition & behavioural predictions

3rd Enabler
CCPU & safety layer

4th Enabler
Novel HMI elements

5th Enabler
Methodology for assessing the quality of interaction

The interACT project aims to address the challenge of integrating Automated Vehicles into mixed traffic environments. Four key enablers are identified:

1. Psychological models
2. Intention recognition & behavioural predictions
3. CCPU & safety layer
4. Novel HMI elements
5. Methodology for assessing the quality of interaction
The challenge

5th Enabler
Methodology for assessing the quality of interaction

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Novel HMI elements

3rd Enabler
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Intention recognition & behavioural predictions

1st Enabler
Psychological models

Achieve a safe, highly accepted and efficient integration of Automated Vehicles in mixed traffic environment
OBSERVATIONAL STUDIES
Key objectives of the observational studies

• **Observe** human-human interactions in current complex urban environments
• Observe human-human interactions in current complex urban environments

• **Model the interactions** using different approaches:
  • Interaction vocabulary: *How do Traffic Participants communicate and anticipate intent*
  • Interaction sequences: *What is the general interaction process in specific use cases and scenarios and what are the cultural difference?*
  • Quantitative models: *How can interactions be mathematically formulated to allow model-in-the-loop simulations?*
Key objectives of the observational studies

• Observe human-human interactions in current complex urban environments
• Model interaction using different approaches
  • Interaction vocabulary: *How do TPs communicate and anticipate intent*
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• Develop real-time **situation and intention analysis** algorithms based on the interaction models
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Observe, Model, Predict
Methodology

- 3 Countries: Greece, UK, Germany
- 4 urban use cases

Data assessment
- Videos
- Observation Protocols
- Questionnaires
- LiDAR
Designing cooperative interaction
Preliminary Results – Manual Observation

- Over 100 Protocols per use case and country
- Also: combined 100+ hours of videos, 20+ hours of LiDAR Data and 150+ people interviewed
Preliminary Results – Manual Observation

“Interaction Sequence” – Intersection – pedestrian goes first:

- Slows down (50, 43, 18) / keeps pace (48, 30, 77)
- Turns indicator (83, 12, 14)
- Decelerates for traffic (49, 16, 11)
- Looks at approaching vehicle (43, 59, 78)
- Initiates Crossing (92, 74, 95)
- **Waives hand (1, 4, 2)
- Looks at Pedestrian (6, 13, 18)
- Decelerates (22, 26, 12) or stops* (5, 23, 1) for pedestrian
- Passes behind pedestrian

Percent of Observed Patterns in:
- Leeds, UK
- Munich, Germany
- Athens, Greece

*at times there is no complete stop but rather a continuation of the movement at a very slow pace

**in some cases there was no hand waiving and the scenario played out comparably
Overall findings

• The occurrence and necessity of interactions depends on the situation and a variety of other factors, such as traffic density, time of day and specific traffic conditions.

• Explicit communication (e.g. gesturing, flashing lights etc.) happens rarely - most potential interaction-demanding situations are resolved before they actually arise, mostly by adjusting kinematic motion.

• Cooperation, communication and thus interaction between human road users takes place at low speeds, usually below 20 km/h.

• At higher speeds, conflict avoidance is predominant – pedestrians use large enough inter-vehicle gaps to cross without expecting the second vehicle to adapt.
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Methodology for assessing the quality of interaction

Designing cooperative interaction - 17/09/2018 - Anna.Schieben@dlr.de
HMI DESIGN
Design considerations for automated vehicles

ITERATIVE DESIGN PROCESS

DESIGN

EVALUATE

PROTOTYPE
Design considerations for automated vehicles

Iterative Design Process

- Design
- Evaluate
- Prototype
Design considerations for automated vehicles

Which information could be needed by other road users?

- **Category A: Vehicle driving mode**
  - Automated or manually driven vehicle
- **Category B: Vehicle’s next manoeuvres**
  - E.g. Vehicle will start moving
- **Category C: Perception of environment**
  - E.g. pedestrian is detected
- **Category D: Cooperation capability**
  - E.g. Vehicle willing to cooperate, gives right of way

Design options

Design of infrastructure
- Separated tracks, signs
Design options

Design of infrastructure
• Seperated tracks, signs

Design of vehicle shape
• E.g. Google car
Design options

Design of infrastructure
• Separated tracks, signs

Design of vehicle shape
• e.g. Google car

Design of vehicle movements
• e.g. approaching behaviour
Design options

Design of infrastructure
• Separated tracks, signs

Design of vehicle shape
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Design of external HMI
• Visual, acoustic signals
Design options

Design of infrastructure
• Separated tracks, signs

Design of vehicle shape
• e.g. Google car

Design of vehicle movements
• e.g. approaching behaviour

Design of external HMI
• Visual, acoustic signals
Interaction strategies: Perception-signalling design
Interaction strategies: Intention-signalling design
CONCLUSIONS
Some (preliminary) conclusions

• The use of “external Human Machine Interfaces” is seems to be especially relevant in **ambiguous situations**, when explicit communication is necessary above and beyond **kinematic cues**

• **BUT** – Unlike manually driven vehicles, in addition to adapting their movement, perhaps Automated Vehicles could **enhance acceptance, safety and traffic flow** by communicating to other traffic participants earlier.
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Thank you for your kind attention!

Anna Schieben
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Project info:
www.interact-roadautomation.eu

Webinar: https://www.interact-roadautomation.eu/cad-webinar-series-ix-interact-project/