Automated vehicles in mixed traffic environments
The interACT Project

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Institute of Transportation Systems, DLR e.V.
ISO Meeting, 18.10.2018
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

interACT /ISO meeting, 18/10/2018, Milano
interACT project facts

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

Programme: EU/H2020-ART04 - Safety and end-user acceptance aspects of 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 challenge

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OBSERVATIONAL STUDIES
Objectives of the studies

• Observe human-human interactions in current complex urban environments

• Model interaction using different approaches
  – Interaction vocabulary: *How do TPs communicate and anticipate intent*
  – Interaction sequences: *What is the general interaction process in specific use cases, scenarios and scenes?*
  – Quantitative models: *How can interactions be mathematically formulated to allow model in the loop simulations?*

• Develop real-time situation and intention analysis algorithms based on the interaction models
  
  **Observe, Model, Predict**
Methodology

• 3 Countries: Greece, UK, Germany

• 4 urban use cases

Data assessment
• Videos
• Observation Protocols
• Questionnaires
• LiDAR
Observation sites
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
# Interaction vocabulary

<table>
<thead>
<tr>
<th>Traffic Participant</th>
<th>type of physical signifier</th>
<th>Sign type (physical signifier)</th>
<th>examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver's behaviour</td>
<td>Hand gesture</td>
<td>e.g. move hand sideways, show palm</td>
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<tr>
<td></td>
<td>Head Nodding</td>
<td>e.g. sideways, downwards, ...</td>
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<tr>
<td></td>
<td>Eye-contact</td>
<td>e.g. with pedestrian, with other driver</td>
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<tr>
<td>Car</td>
<td>Car movement</td>
<td>e.g. accelerate, kept pace, stopped, turned</td>
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<td></td>
<td>Car positioning</td>
<td>e.g. protruding on intersection, keeps left/right</td>
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<td>Engine noise</td>
<td>e.g. rev-up the engine on idle</td>
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<tr>
<td>Car HMI</td>
<td>Turn indicator</td>
<td>Left / right</td>
<td></td>
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<tr>
<td></td>
<td>Headlights flashing</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Horn</td>
<td>e.g. one long press, one momentary, two...</td>
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<td>Alarm indicator</td>
<td></td>
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<tr>
<td>Pedestrian</td>
<td>Hand gesture</td>
<td>e.g. raised hand, extending palm, waving, ...</td>
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<tr>
<td></td>
<td>Head Nodding</td>
<td>e.g. sideways, downwards, ...</td>
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<tr>
<td></td>
<td>Eye-contact (with car driver)</td>
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<td></td>
<td>Gaze towards car (when it is clear that the pedestrian has seen the car)</td>
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<td>Head/body orientation (combined since semantically they form a whole)</td>
<td>e.g. facing car, facing sideways, ...</td>
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<tr>
<td></td>
<td>Body movement</td>
<td>e.g. walking parallel towards car, hesitating, accelerating, ...</td>
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</table>
Preliminary Results – Manual Observation

“Interaction Sequence” - Intersection – pedestrian goes first:

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

*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 waving and the scenario played out comparably
Driver-driver interaction

Figure 37: Sequences of observed signals/cues in interactions between drivers relevant to left turns
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.

• At higher speeds, conflict avoidance is predominant – pedestrians use large enough inter-vehicle gaps to cross without expecting the second vehicle to adapt.
Some (preliminary) conclusions

• The use of “external Human Machine Interfaces” is only 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.
HMI Design
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 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-signaling design
Interaction strategies: Intention-signaling design
Further project information

www.interact-roadautomation.eu

Twitter: @interACT_EU

Deliverables: https://www.interact-roadautomation.eu/projects-deliverables/

Webinar Results Observational studies:
https://www.interact-roadautomation.eu/cad-webinar-series-ix-interact-project/
https://www.youtube.com/watch?v=in4eTz1f5Fc&feature=youtu.be

Webinar Technical Approach:
https://www.youtube.com/watch?v=Xy2soHjSAxY&t=11s
Thank you

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