DAVI and the Frontiers of Automated Driving

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• Introduction to DAVI
• What is automated driving?
• Multidisciplinary frontiers
  • Technology
  • Human factors
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• Dutch Automated Vehicle Initiative (DAVI)
What is automated driving?

- Partial automation
- High automation
- Full automation
Driver assistance systems

Front camera:
- Audi active lane assist
- ACC stop go
- Speed limit display
- Audi pre sense / front / plus
- Traffic sign recognition
- Full continuous headlight range control

Ultrasonic sensors at front:
- ACC stop go
- ACC dynamic assist
- Pre sense / front / plus
- Night vision camera with highlighted pedestrian detection

InfraRed camera:
- Night vision camera with highlighted pedestrian detection

Front radar sensors:
- Audi pre sense / front / plus

Ultrasonic sensors at side:
- Park assist

Rear camera:
- Parking system plus with reversing camera
- Park assist with reversing camera

Ultrasonic sensors at rear:
- Parking system
- Park assist

Rear radar sensors:
- Audi side assist
- Audi pre sense rear / plus

Crash sensors:
- Front protection (pedestrian)
- Side protection
- Rear impact protection

Under the bonnet

How a self-driving car works

Signals from GPS (global positioning system) satellites are combined with readings from radar, ultrasonic and infrared sensors to provide an accurate picture of the car's surroundings. This information is used to adjust the settings on the car's dashboard, such as the settings for the cruise control.

Radar sensors

Ultrasonic sensors may be used to measure the distance to objects very close to the vehicle, such as cars and other vehicles when parking.

Lidar (light detection and ranging) sensors bounce pulses of light off the surroundings. These are analysed to identify lane markings and the edges of roads.

Video cameras detect traffic lights, road signs, and other vehicles.

The information from all of the sensors is analysed by a central computer that manipulates the steering, accelerator and brakes. Its software must understand the rules of the road, both formal and informal.

Radar sensors monitor the position of other vehicles nearby. Such sensors are already used in adaptive cruise control systems.

Source: The Economist
The technology frontier

- Reliable Environment Perception - Sensing
- Robust / fail safe control – Algorithms
- Communication
- System safety
- Security

Human factors
Observations and questions

• Self-driving cars compete with train?
• How did she leave home?
• How did she transfer control?
• What if she doesn’t resume manual control?
• (just a button to resume control?)

The human factors frontier

• Positive attitude
• Valuation of time
• Safe transition of control
• The remaining role of the driver (if any)
• Driving skills
• Acceptance
• Perceived safety
The traffic management frontier

Potential impacts

- Solve traffic jams by increased outflow
- Prevent traffic jams by better stability
- Better distribution of traffic over network
- Less congestion delay
- Better travel experience
- No accidents
- Better energy efficiency
### Automation stages in longitudinal driving

<table>
<thead>
<tr>
<th>Stage</th>
<th>Sensor(s)</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual driving</td>
<td></td>
<td>Flexible, efficient, anticipative Low precision, can get tired and fail</td>
</tr>
<tr>
<td>Adaptive Cruise Control</td>
<td>Radar/camera</td>
<td>Precise, fast, constant No anticipation, unstable</td>
</tr>
<tr>
<td>Traffic Adaptive Cruise Control</td>
<td>Radar/camera V2x communication</td>
<td>Precise, fast, stable Efficient?</td>
</tr>
<tr>
<td>Platooning</td>
<td>Radar/camera V2x communication Coordinated control</td>
<td>Precise, fast, stable, efficient ?</td>
</tr>
</tbody>
</table>

### Cooperative Eco ACC

- Each follower minimizes own cost
- Followers jointly minimize total cost
- **W-LAN IEEE 802.11p**
The platooning dilemma

- 15 km/l
- 15 km/l
- 16 km/l
- 18 km/l
- Who goes first?

Transport and spatial impacts

- Automation a case for car sharing
  - What about Evs?
- Demand responsive cars
- Travel time becomes useful: the end of Brevers’ law?
- No need for on-street parking
  - Just pick-up and drop-off?
  - New urban designs
- Design of roads and junctions?
The traffic management frontier

- Impacts on traffic flow efficiency
  - Good or bad?
- Consequences for infrastructure
  - Markers, i2v communication
- Impacts on car ownership and use
- Impacts on spatial design

The laws and regulation frontier

- Liability
  - Type approval
  - Driver responsible
- Traffic regulations
  - As many as we have member states...
  - Can an automatic car get a speeding ticket?
- Testing procedures
  - Unavailable, moving target?
Geneva Convention on Road Traffic, European Member States Article 8.5

“Drivers shall at all times be able to control their vehicles or guide their animals. When approaching other road users, they shall take such precautions as may be required for the safety of the latter.”

Frontiers that were no frontiers....

- Electronic braking
- Adaptive Cruise Control (including braking)
- Lane Keeping
- Adaptive Cruise Control and Lane Keeping
- Automatic Emergency braking
The laws and regulations frontier

• Laws and regulations
  - Type approval
  - New flexible testing procedures
  - Liability
  - Special permits

• Policy development
  - Infrastructure and environment
  - Economy and innovation
  - EC
Melanie Schulz van Haegen
Dutch Minister of Infrastructure and Environment

60% automated cars in 2023, 100% in 2033

Approach DAVI

• Study human behaviour with automation
• Assess & improve the technology of automated driving
  • Start sensor based, add communication later
• Quantify benefits at individual & network level
• Create public awareness and study acceptance of automated driving
• Pursue first steps in legalisation of automated driving
• Public roads (DITCM) and proving ground (RDW)
DAVI road map

Research

- Environment perception
  - Reliability quantified & improved in varying road & weather conditions
  - Fail safety
  - Low cost solutions (stereo camera, radar)

- Human behaviour
  - Transition of control (Driver – 2 – vehicle etc)
  - Subjective evaluation of user acceptance and trust
  - Interface design & evaluation
  - Modelling behavioural adaptation

- Safety / traffic efficiency / fuel economy
  - Traffic model simulations
  - Predict benefits (and risks) before market introduction
  - Explore legalisation including type approval procedures
Current DAVI projects

• Truck Merging Support - a Step towards Autonomous Driving, HTSM Automotive (2013-2016).
• Connected Cruise Control (CCC), HTAS Innovation 2009-2013.
• Model predictive control framework for Cooperative Intelligent Vehicles (Shell, 2010-2014).
• Reducing congestion at sags by cooperative intelligent vehicles (Toyota, 2011-2015)
• High Performance Vehicle Streams (FHWA/UC Berkeley, 2013-2015)
• Vehicle automation and infrastructure investments (I&M, in preparation)

Related projects

• Cooperative ITS Corridor Rotterdam-Vienna
• Dutch Integrated Test Site for Cooperative Mobility

DAVI and education

• CIE 5805 Intelligent Vehicles
• CIE 4821 Traffic flow theory and simulation
• CIE 4831 Empirical Analysis for Transport and Planning
• SPM 9425 Intelligent Transport Systems
• ME 1130,1140,1150 Robotics courses
• WB 2306, 2404 Human controller/man-machine systems
• SC 4040, 4060 Filtering , identification, model predictive control
• (…)
• TIL 5050 Integral design project
• MSc projects
• iGame Challenge 2013-2016
  • Grand Cooperative Driving Challenge
  • Multi-team, multi-vendor scenarios
  • A270
• Riender Happee, Raymond Hoogendoorn, Manuel Mazo Espinoza
Cars automatic in 20 years

Tell it we don’t appreciate these types of jokes and to come back right away

Thank you!