State of the art in autonomous driving

German Aerospace Center DLR
Institute of transportation systems

Smart Cities Symposium Prague 2017
Dr.-Ing. Reza Dariani

Knowledge for Tomorrow
DLR at a glance

Deutsche Zentrum für Luft- und Raumfahrt (DLR)

German Aerospace Center

- 8000 employees
- 20 locations in Germany

Institute of transportation systems:
- Automotive
- Railway Systems
- Traffic Management
Why Autonomous Vehicles?

1. Safety Vs. Human error

- Reason of most accidents (94%) is driver error.
- High speed, seat belt, drink driving, age, fatigue, ...
- Slow reaction time

- Initial accel release: 1.28 sec.
- Total brake (to max): 2.3 sec.
- Time to initial steering: 1.67 sec.

2. Congestion cost and traffic

3. Fuel efficiency

4. Comfort

2016 = 3.2 (preliminary)
Front seatbelt mandatory
ESC installation rate >80%
Autonomous vehicles from illusion to reality

• First idea: In the World’s Fair of 1893 in New York, General Motors presented vision of “driverless cars”.

• Three main stages of research:
  • 1980-2003: University researchers developed AVs in two groups
    • Dumb vehicle, smart dedicated lanes → Vehicle relies on infrastructure
    • Automated vehicles
  • From 2003: DARPA Grand challenges boosted research
  • Recently private companies and vehicle industries have advanced AVs
Different level of automation

Level 0: No Automation
Level 1: Driver Assistance
Level 2: Partial Automation
Level 3: Conditional Automation
Level 4: High Automation
Level 5: Full Automation

Driver monitors driving environment
Electronic system monitors driving environment

SAE international’s J3016
**Different level of automation**

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Execution of steering and acceleration/deceleration</th>
<th>Monitoring of driving environment</th>
<th>Fallback performance of dynamic driving task</th>
<th>System capability (driving modes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
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- Examples (*Series production*): Lane Departure Warning, Forward Collision Warning, Blindspot Detection, Lane Change Decision Aid, Parking Sensors, Adaptive Front-lighting
## Different level of automation

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<tbody>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>Human driver and system</td>
<td>Human driver</td>
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- Examples (*Series production*): Adaptive Cruise Control, Parking Assist (only lateral control)
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<tr>
<td>2</td>
<td>Partial Automation</td>
<td>System</td>
<td>Human driver</td>
<td>Human driver</td>
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- Examples *(Series production)*: Traffic Jam Assistant, Parking Assist (longitudinal and lateral control), Tesla Autopilot
Different level of automation

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<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>System</td>
<td>System</td>
<td>Human driver</td>
<td>Some driving modes</td>
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• Examples (Research & Development): Highway Chauffeur, Platooning
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<td>4</td>
<td>High Automation</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some driving modes</td>
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- **Examples (Series):** People Mover (on constructional separated lanes), Automated transport of goods on factory premises
- **Examples (Research & Development):** Google car, People Mover (on public roads), Automated Valet Parking, various research projects
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<td>5</td>
<td>Full Automation</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>All driving modes</td>
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- A vehicle with an automated driving system that, once programmed with a destination, is capable of fully performing the dynamic driving task throughout complete trips on public roadways, regardless of the starting and end points or intervening road, traffic, and weather conditions.

- Degree of maturity: Research

- Currently no systems available, which are capable of this.
Technological basis for automated driving
Technological basis for automated driving
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Cooperative lane changing with V2V communication
Highly-automated valet-parking
Outlook

Managing Automated Vehicles Enhances Network (MAVEN)
State of the art in autonomous driving

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