Establishing a Standard List of Hazards for Automatic Driving

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Overview

- Introduction & motivation
- The role of hazard identification in the safety process
- Hierarchy of hazards and causes of hazards
- Progress to date
- Future work
“It’s a pretty exciting moment in the history of the path to wide scale [autonomous vehicle] deployment and having the first production car with no driver controls,” GM President Dan Ammann told The Verge. “And it’s an interesting thing to share with everybody.”

Headline – “Waymo (Google) to Buy Up to 62,000 Chrysler Minivans for Ride-Hailing Service”

A Chrysler Pacifica minivan outfitted with Waymo self-driving technology in Mountain View, Calif., last summer. Waymo’s plan to buy up to 62,000 of the minivans signals its ambitions for a driverless ride-hailing service. Jason Henry for The New York Times

Headline – “Ford and Lyft will work together to deploy autonomous cars”

The emergence of self-driving cars, estimated to eventually be a $7 trillion industry, has spurred almost too many partnerships and collaborations among automakers, suppliers, and tech startups to count.

Ford Motor Co. and Lyft Inc said they would develop self-driving vehicles for the ride-hailing service, adding to a growing number of alliances between automakers and tech companies jockeying for control of the road. WSJ - Sept. 2017

Ford seems determined to meet its 2021 deadline to launch a service in the United States using its self-driving cars. And it’s not talking about some small test operation in a single city — it wants to launch and operate its own service “at scale,” with all the necessary components in place to ensure it’s both efficient and profitable. www.digitaltrends.com
Headline – “Driver Killed in Tesla Self-driving Car Crash Ignored Warnings, NTSB reports”
Self-Driving Uber Killed a Pedestrian in Arizona

https://www.youtube.com/watch?v=MzpGae3Eies
One Plan for Maturing the Safety of Self-driving Cars

Looking for volunteers for the next beta version of software
Accepted Approach for Developing Safe Systems

- Identify system hazards
- Evaluate the mishap risk from these hazards
- Classify / quantify hazards by risk level
- Develop appropriate risk mitigations
- Evaluate risk improvement
- Gain approval that reduced risk is acceptable

Focus of the work was to take the first step, hazard identification

Mil-Std-882 and others

These steps are repeated during:
- Concept development
- Design
- Deployment

Hazards – a condition that could cause death, damage, etc
Mishap – unplanned event that results death, damage, etc
What are Self Driving Car Hazards?

• **My Focus** - Conditions that **may** result in collisions
  • Collisions - Impact with other vehicles, stationary objects (including terrain), bicycles or pedestrians.
  • Standard (Generic) Hazard – Hazards associated with motor vehicle operation, independent of a particular design
  • Although objective is self-driving cars, most standard hazards apply to human driven cars

• **Identification of “standard” hazards appears useful**
  • A framework for safety assessment
  • Useful to all developers, uniform approach
  • Useful for regulators and legal use
  • Could be independently developed / maintained by a standards organization

• **Goal is hazard mitigation (risk reduction)**
  • Identify design features linked to standard hazards
  • Design to mitigate the hazards
Hazard Hierarchy for Collision Mishaps

Just an illustration – Many hazards not yet identified
Need a Method to Identify Standard Hazards

• This work attempted to identify standard hazards using a student driver analogy
• Using this analogy, the new driver is exposed to progressively more hazardous driving scenarios
  • Operate on back roads without other traffic (empty back road)
  • Include other vehicles on back roads in clear weather (back road with other traffic)
  • Include pedestrians, bicycles and animals on back roads in clear weather
  • Operate in darkness, adverse weather, hazardous roadways
• Driving scenarios are “use cases” for revealing hazards
Method was Useful in Identifying Standard Hazards

<table>
<thead>
<tr>
<th>Table 1 — Empty Back Road Hazards</th>
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</thead>
<tbody>
<tr>
<td>Departure from road surface</td>
</tr>
<tr>
<td>Departure from travel/turning lane</td>
</tr>
<tr>
<td>Fail to avoid stationary objects in roadway</td>
</tr>
<tr>
<td>Fail to obey traffic signs</td>
</tr>
<tr>
<td>Fail to observe intersection traffic laws</td>
</tr>
<tr>
<td>Exceeding vehicle performance limits</td>
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<tr>
<td>Do not become a slow/stopped road obstacle</td>
</tr>
<tr>
<td>Fail to obey traffic signals</td>
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<tr>
<td>Fail to obey lane markings</td>
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</tbody>
</table>
Another Example - Identifying Standard Hazards

<table>
<thead>
<tr>
<th>Table 2 — Back road with other traffic</th>
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<tbody>
<tr>
<td>Failure to maintain safe separation distance from other vehicles</td>
</tr>
<tr>
<td>Failure to stop for other vehicles</td>
</tr>
<tr>
<td>Failure to yield to other vehicles</td>
</tr>
<tr>
<td>Improper passing</td>
</tr>
<tr>
<td>Fail to signal for turn</td>
</tr>
<tr>
<td>Fail to follow intersection rules of the road</td>
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</tbody>
</table>
Environmental Conditions Increase Risk Levels Rather than Reveal New Hazards

Operate in darkness or adverse weather

- Darkness/ adverse weather not a new hazard, but increases the risk level of standard hazards (poor visibility increases risk of: Departure from road surface; Fail to avoid stationary objects in roadway; Fail to obey traffic signs)
Thorough Standard Hazard Identification is a Formidable Task

- Author only identified a small number of hazards
- Student driver analogy useful, but would benefit from involvement of driver training instructor
- Many possible road design hazards, traffic signal scenarios and traffic law nuances – suggested references
  - AAA. (2013). *HOW TO DRIVE INSTRUCTOR GUIDE*
- Many special scenarios – construction, tunnels, ferry boats,…

Future work could be guided by the suggested references
Summary / Conclusions

- Achieving self-driving car safety requires understanding of hazards
- Self-driving car developers, regulators, legal professionals and ultimately the driving public would benefit from a catalog of standard driving hazards
- Cataloging these hazards is a significant undertaking that the author only just started
- Much additional work is needed to identify the underlying causes of these hazards and to devise effective mitigations (unique to each design)
- The author sees no alternative to a thorough understanding of hazards to support self-driving car safety evaluation