

Self-Driving Vehicles

The Quintessential Example of Next-Gen Cyber-Physical Systems

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MOTIVATION

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Motivation for Self-Driving Vehicles

- 1.3 million people die every year globally due to automotive crashes
 - About 94% of these crashes happen due to human error
- Traffic delays are very expensive
- The elderly, legally blind and physically disabled people have to often depend on others for transportation
- Car sharing is transforming car ownership and the transportation industry

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CHALLENGES

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The “Uncertainties of the Road World” Challenge

Dealing with the uncertainties of an unconstrained road-world operating environment

- Highways, urban, suburban, ex-urban and rural roads
- Accidents, Emergency Vehicles
- School zones, kids, the elderly, strollers, wheelchairs, jaywalkers and absend-minded crossing
- Weather conditions
- Road conditions
- Lighting conditions
- Construction zones
- Wild life

Uncertainty to the power of n , where n is large

→ Is the list of scenarios even finite?

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The Verification Challenge

- Can we prove the following proposition?
- The **strong** version:
 - *Given a vehicle with its AV hardware* and software** stack, the vehicle will behave safely under all possible conditions*
- The **weak** versions:
 - *Given a vehicle with its AV hardware and software stack, the vehicle will behave unsafely under only a known set of conditions*
 - *Given a vehicle with its AV hardware and software stack, the vehicle will behave safely under a known non-trivial set of conditions.*

* Compute h/w, sensors, actuators, networks

** Entire stack from sensor processing to actuation decisions

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Other Challenges

- The Non-Cooperation Challenge
- The Fault-Tolerance Challenge
- The Cyber-Physical Security Challenge
- The “Co-Existence with Human Drivers” Challenge
- The Perception Challenge
 - minimizing false positives *and* false negatives
- Legal and Regulatory Challenges
- The “Customizability to Different Countries & Driving Cultures” Challenge
- The Ethics Challenge
- The “Knowledge Encoding” Challenge
- The “Human Expectation and Comfort” Challenge
- The “Dealing with Pranksters” Challenge

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TURING, WHERE ART THOU?

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A Turing Test for Automated Vehicles

- If a self-driving vehicle cannot be distinguished from a human-driven vehicle by humans outside the vehicle, it is said to have passed the Turing Test for Automated Vehicles.

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More on the Turing Test

- Functionality
- Aesthetics
- Interactions with other vehicles and humans (pedestrians, bicyclists, ...)

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Enhanced Turing Test for AVs

- In the future, AVs may be accorded special privileges
 - Dedicated lanes, precedence at intersections to maximize throughput, platooning, ...
- An Enhanced Turing Test for AVs will need to account for these special privileges

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