Automated Vehicles & Safety

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Autonomous Vehicle Proposition

- Driver errors cause >90% of accidents

- Including drivers in the loop is not sensible, and drivers can’t be expected to take over safely or effectively.

- Let’s do without Drivers!
Things Could Still Go Wrong, Even if Vehicles are Automated?
Tesla Fatality Incident (May 2016, Florida)

- Neither human nor the machine hits the brake.
- Driver’s hands on wheel for only 25 seconds during 37-minute period
- Driver ignored 7 visual warnings and 6 audible warnings during the trip
- Tesla cruise control set at 74 mph.
- Driver has at least 3.4 seconds to react.
Questions and Comments

• Supposedly, the driver should still be monitoring the Driving environment. (SAE Level 2)
  • Can we expect drivers to be continuously vigilant?

• Why did the Tesla not slow down?
  • Apparently, the “detection/perception” function failed for the ADS to timely react to the situation.

• Can new generation of technologies, such as Artificial Intelligence, help?
Recent UBER Incident (March 2017, Arizona)

- UBER car has the right of way, per police report.
- The left-turn car was “at fault,” and cited.

- Two inside lanes were grid-locked. (orange)
- The outside lane was clear to proceed. (green)

- Did the UBER car try to “rush through the intersection”?
- Did it make a good judgment?
Questions and Comments

• How will a (conservative) human driver behave if he is in the UBER car?
  • Slow down as it approaches, given that the left-lane traffic is congested and partially blocking the view?

• Is this a failure in decision making and driving behaviors?
  • Defensive driving in anticipation of other road users

• Can new generation of technologies, such as AI, help?
Recent Cruise Automation Incident (December 2017, SF)

- Cruise AV intends to change lane, but a van in front slows down
- As Cruise AV aborted a lane change and was re-centering itself in the lane,
- **A motorcycle** that had just lane-split between two vehicles moved into the center lane, glanced the side of the Cruise AV, wobbled, and fell over.
- At the time of the collision,
  - Cruise AV was traveling with the flow of traffic at 12 mph
  - Motorcycle at approximately 17 miles per hour.
Questions and Comments

• How well can the CA car see the surrounding?
  • Highly instrumented with 3-5 lidars and multiple cameras, plus radar.

• Is an evasive movement possible, to avoid contact with the motorcycle?
  • Approach speed and trajectories of other road users

• Can new generation of technologies, such as AI, help?
Recent UBER Incident (March 2018, Tempe)

- Pedestrian walking bike and crossing 2-lane roadway
- Uber vehicle in automation mode cruising at **38 mph**.
- Assuming **ped+bike** is walking 2-3 mph, which is equivalent to 2.93-4.40 ft/sec, it takes **4-6 seconds** to cross one and a half lanes.
- UBER car, if all sensors function properly, will begin to see ped+bike when **half-way into the opposite lane**, at **3-4 seconds** before the crash, at **167 to 223 feet** away.
- Stopping time for 38 mph by reasonable hard braking (0.7g) takes **2.47 seconds** or 69 feet.
- Driver perception and reaction time takes **1.5-2.5 seconds**, so the human driver could barely stop in time.
Questions and Comments

• Could the driver possibly avoid the accident?
  • Not if the driver is not paying attention
  • Could have slowed down the car

• Could the “machine” see the pedestrian crossing and stop in time?
  • Possibly yes, with lidar and radar
  • Reportedly, lidar was “turned off”

• Can new generation of technologies, such as AI, help?
Safety Challenges in Real World

• These accidents may be the first to draw attention,
  • But, they won’t be the last

• There is usually a prime culprit of functional failure in the system,
  • But, multiple causes/ factors are often involved

• The real world is very complicated
  • How much testing is needed?
  • How do we verify safety?
Challenges in AV Testing and Safety Verification
How Much Testing Is Needed?  
Compared to Benchmark (Human) Performance

The National Safety Council of US reports a rate (including deaths of pedestrians and cyclists killed in motor vehicle accidents for all roads) of
- 1.25 deaths per 100 million vehicle miles, or
- 12.5 deaths per billion vehicle miles) traveled in 2016.

- 80 million vehicle-miles per fatality
  ~ = 1 person, 20,000 miles/ per year X 50 years X 80 life-times, or
  ~ = 4,000 cars X 20,000 miles/ per car per year (production), or
  ~ = 100 cars X 160,000 miles/ per car per year X 5 years (prototype)
How to Expedite Learning and Testing?

- **Practices of Safety Assurance Testing:**
  - Learn from database of “corner cases”
    - Collection of challenging scenarios and test cases
  - “Fleet” Learning, e.g. Tesla
    - > 100k vehicles, >1.3B miles driven, >300M miles with AutoPilot on
  - “Simulated” Learning, e.g. Waymo CarCraft
    - > 25k virtual vehicles, >8M miles daily, >2.5B miles yearly

- Advanced computational technologies and AI can help.
Safety Risks

- Safety Risk = Exposure \times Severity \times Controllability

- Fixed-route, slow-moving (driverless) shuttles minimize safety risks.

- Driverless Automated Mobility Services (Robot-Taxi) must perform well to avoid risks.
Thank you.

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