Automated Vehicles: Challenges and Opportunities
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Outline

• Let’s Get our Terms Straight
• Why I Get to Talk About This
• When Things Go Wrong
• Whose Fault Is It?
• Where Are We Headed?
Let’s Get our Terms Straight
ADAS vs SDC

Source: *Last Man Standing*, ABC Television, 9/30/2016
ADAS vs SDC

• ADAS: Advanced Driver Assistance Systems
  – Adaptive Cruise Control
  – Emergency Braking (Front / Rear)
  – Blind Spot Monitoring
  – Lane Departure Warning
  – Lane Keeping Assist
  – Active Park Assist
  – Pedestrian Detection
  – Autopilot
  – Driver is required to monitor

• SDC: Self-Driving Cars
  – All of the above features and much more, all integrated
  – Driver is not required, at least in defined-use cases
Adaptive Cruise Control

• Cruise Control that slows down to maintain Time Gap (Time Headway) from car in front

• Mercedes was first in 1998 (Distronic)
Emergency Braking

• Audi Pre-Sense

1st phase
- Optical and acoustic warning
- Shock absorber adjustment
- Precharging of hydraulic brake assist

2nd phase
- Warning jolt
- Belt slack reduction
- Partial braking 1 (approx. 30%)

3rd phase
- Partial braking 2 (approx. 50%)
- Hazard warning lights
- Closing of sunroof / windows

4th phase
- Reversible belt tensioner
- Full brake

4th phase
3rd phase
2nd phase
1st phase
Blind-Spot Monitoring

- VW Blind Spot Monitor
Lane Departure Warning

• Volvo LDWS
Lane-Keeping Assist

• Ford LKAS
Active Park Assist

• Ford APA
Pedestrian Detection

- Volvo PDS
Why I Get to Talk About This
Variable Time-Headway (VTH)

• Adaptive Cruise Control (ACC) traditionally uses \textit{time headway} spacing: follow x seconds behind the car in front (independent of speed)

• In the real world, sensor and actuator delays create instabilities that may lead to crashes in platoons of ACC-enabled vehicles

• While at UCLA in the ‘90s, my then-student Diana Yanakiev (now at Uber ATC) and I developed \textit{variable time headway} spacing
Variable Time-Headway (VTH)

- **Reduce** time headway if the leading car is traveling **faster**, **increase** time headway if the leading car is traveling **slower**
VTH Simulation

Source: UCLA Adaptive & Nonlinear Systems Lab, 10/1996
VTH Experimental Test

Source: California PATH / UCLA Adaptive & Nonlinear Systems Lab, 08/1999
IRIS Sensor for ADAS

Regular scene

IR LED ON

IR LED OFF

Subtracted image

Source: UCLA EE Department, 1996, with O. M. Stafsudd, P. R. Nelson, N. Bambos
Iperasys: An ADAS Startup
When Things Go Wrong
Main Concerns about ADAS/SDC

• Malfunction concerns
  – Ghost targets (false positives) may cause rear-end collisions
  – Missed targets (false negatives) are even worse
  – Unexpected swerving, braking, etc.

• Cyber-security concerns
  – If the car is a computer, it can be hacked
ACC False Negatives

• Typically seen with stationary objects
• Here is such a “dummy” object:

Source: YouTube, [youtu.be/hl0LCOIW_SI](youtu.be/hl0LCOIW_SI)
ACC False Negatives

• Amateur test using Audi A6

Source: YouTube: youtu.be/hI0LCOIWW_SI
ACC False Negatives

- Professional test using Volvo S60

Source: YouTube, youtu.be/jClxcSBNwcw
What Happened There?

• The easy answer is to blame radar
• All the incidents involved stationary objects
• Radar has trouble “seeing” stationary objects because they blend into the background
• What can be done?
  • Sensor fusion: Radar + Camera + Lidar + …
  • But most cars today claim to use sensor fusion, and yet problems occur all the time
• So... is the radar really at fault?
Lane Keeping Assist Swerving

• Real-world mishap in Tesla Model S

Source: YouTube, youtu.be/MrwxE8qOxA
Lane Keeping Assist Swerving

- Another real-world mishap in Tesla Model S

Source: YouTube, youtu.be/pw2mUhLtYBk
Pedestrian (Un?)Detection

• Volvo pedestrian detection “test”

Source: YouTube, youtu.be/w2pwxv8rFkU
Car-jacking -> Car-hacking

• This is just fantasy, right?

Source: *Fast & Furious 6*, Universal Pictures, 2013
Car-jacking -> Car-hacking

• Nope! Reality is even worse!

Whose Fault Is It?
Assigning Responsibility

• Tests and demos are one thing; we can laugh them off
• But real-world accidents trigger insurance claims and lawsuits and recalls
• With today’s ADAS, the standing assumption is that the driver is responsible
• Will insurance companies take on the risk of insuring SDC owners?
• And who will be blamed for SDC accidents?
  – Driver? Manufacturer? Hacker?
ACC False Negative

• Real-world mishap in Tesla Model S

Source: YouTube, youtu.be/qQkx-4pFjus
Active Park Assist Mishap

• Volvo self-parking fails to detect pedestrians

Source: YouTube, youtu.be/CQZKWA0Yt0Y
What if This Were an SDC?

• Please don’t freak out – wait for the end

Source: YouTube, youtu.be/Khuie6_axRg
And What if THIS Were an SDC?

• OK, you can freak out here

• 27 people were killed in Durban, South Africa
• The truck driver claimed that the brakes failed

Source: YouTube, youtu.be/DAdSrXEPu6Y
Could That Really Happen?

• It already has with ADAS (Tesla Autopilot)


• NTSB investigation still ongoing

So Who Is to Blame?

• Disclaimer: This is only my personal opinion
• There is a long history of human drivers attempting to assign blame to the car’s systems
  – Brake failures
  – Steering failures
  – Exploding tires
  – Accelerating cars
• Sometimes that turned out to be true, other times not
• My view is that the same process will be used to figure out who to blame in accidents involving ADAS/SDC
• For the most part, these issues will be settled in the court system through lawsuits
Where Are We Headed?
What’s Next for ADAS?

• Higher reliability with more development and testing using real-world feedback
• Better sensor integration
• Better integration of individual functions
  – For example, blind-spot monitoring should feed into ACC
• Today: Scene Awareness
  – Each separate system sees only its own “scene”
• Tomorrow: Surroundings Awareness
  – Each system helps each of the other systems
Self-Driving Cars – Why?

• There are some obvious benefits:
  – Better use of time spent in traffic
  – Less traffic, fewer accidents
  – Better mobility for those who cannot drive
  – Quicker pizza delivery (PizzaLyft, anyone?)

• But self-driving cars open up a host of new opportunities in the sharing economy
SDCs in the Sharing Economy

• Cars designed for delivery of goods could be much lighter and emissions-free
  – They may even have a special compartment to bake the pizza on the way...

• Cars designed to carry people could be much safer
  – Non-traditional (safer) seating positions
  – No glass windows (hey, it’s my talk)
  – Better weight distribution for improved handling
SDCs in the Sharing Economy

• Self-driving cars would be better for the environment
  – Fewer human errors, fewer accidents, less traffic, less pollution

• More people would be willing to look at cars as a shared resource
  – Fewer owned cars, more people per car, fewer cars on the road
  – Fewer homes with garages (again, it’s my talk)
SDCs – When?

• Your guess is as good as mine

• Defined-use cases: 3-5 years
  – Uber has been using SDCs in Pittsburgh for about a month, and so far so good
  – Uber and others like it can utilize SDCs much sooner than the general public

• SDCs for the general public: at least 7-10 years
  – Will be expected to perform near-perfectly in all conditions – that’s a very tough problem
SDCs – How?

• Maybe all SDCs will be defined-use cases for the foreseeable future
• In the sharing economy, each of us could simply utilize different types of SDCs (and, in some cases, maybe even cars driven by actual humans) depending on our needs
  – Type A SDC drives kids to school in the morning and picks them up in the afternoon
  – Type B SDC drives adults to work and back
  – Type C SDC drives retirees to their activities
  – Type D SDC drives the whole family and their picnic gear to the beach on the weekend
Conclusions

• ADAS is here to stay
  – But most of these systems need to be further refined

• Self-Driving Cars are coming
  – The potential societal benefits are too big to ignore
  – Lots of work still to be done before they are at a reliability level where the public can accept them

• The “Whose Fault Is It?” question is likely to be sorted out in the courts over several years
For More Information...

MONETIZING THE AUTOMOTIVE INDUSTRY OF TOMORROW

Advanced driver-assist systems (ADAS) will have a $102 billion opportunity by 2030, up from a mere $2.4 billion today, as carmakers rush to add automation features, according to Lux Research.

Source: Informa TMT, tmt.knect365.com/adas-self-driving/