Introduction to Intelligent Vehicles
[5. Advanced Driver-Assistance Systems]

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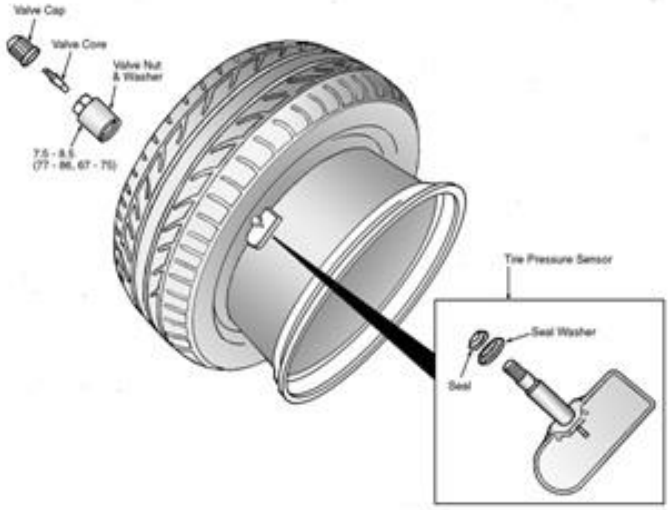
List of (Some) ADAS

- Advanced Driver-Assistance Systems = ADAS
  - Tire-Pressure Monitoring System
  - Navigation System
  - Anti-Lock Braking System
  - Traction Control System
  - Electronic Stability Control
  - Collision Avoidance System
  - Adaptive Cruise Control
  - Lane Departure Warning System / Lane Keeping Assistance
  - Blind Spot Monitor
  - Lane Change Assistance System
  - Surround View System
  - Parking Assistance
  - Automatic High Beams
  - Driver Monitoring System
  - Traffic-Sign Recognition

Tire-Pressure Monitoring System (TPMS)

- What is TPMS?
  - Monitor the air pressure inside the tires
- Why is TPMS helpful?
  - Safety, fuel efficiency, tire wear
- When is TPMS working?
- Where is TPMS working?
- Who develops TPMS?
  - Original Equipment Manufactures (OEMs), suppliers, aftermarket
- How does TPMS work?
  - Direct TPMS vs. indirect TPMS
  - Wireless communication
  - Battery



https://www.moderntiredealer.com/article/312189/register-mazda-sensors-when-changing-tires-or-wheels

Tire-Pressure Monitoring System (TPMS)

❑ Random stuff

- For every 10% of under-inflation on each tire on a vehicle, a 1% reduction in fuel economy will occur [Wikipedia]
- Temperature matters?
  - PV = nRT
- Is it hackable?
- Video: https://www.youtube.com/watch?v=sF3OHTzXIXs

Navigation System

- What is a navigation system?
- Why is a navigation system helpful?
- When is a navigation system working?
- Where is a navigation system working?
- Who develops a navigation system?
- How does a navigation system work?
  - Localization: Global Positioning System (GPS)
  - Map: preinstalled static map, real-time information (traffic)
    - Dynamic map?
  - Shortest path problem?

Navigation System

- Random stuff
  - User interface
  - Video: https://www.youtube.com/watch?v=HGqDRTImexM

Anti-Lock Braking System (ABS)

- What is ABS?
  - Prevent the wheels from locking up during braking
- Why is ABS helpful?
  - Wheel lock-up is dangerous
- When is ABS working?
- Where is ABS working?
- Who develops ABS?
- How does ABS work?
  - Next slide

Anti-Lock Braking System (ABS)

- How does ABS work? [Wikipedia]
  - Monitor the speed sensors and look for decelerations in the wheel that are out of the ordinary
    - If left unchecked, the wheel will stop much more quickly than any car could
  - If a rapid deceleration is "impossible", reduce the pressure to that brake until it sees an acceleration
    - Keep the wheels very near the point at which they will start to lock up
      - This gives the system maximum braking power
  - Replace the need to manually pump the brakes
    - Allow to steer even in most emergency braking conditions

Anti-Lock Braking System (ABS)

- Random stuff
  - The driver will feel a pulsing in the brake pedal [Wikipedia]
    - This comes from the rapid opening and closing of the valves
  - ABS may not be allowed in some racing games
    - Professional drivers can do similar things
  - Video: https://www.youtube.com/watch?v=ru4JIZ-x8yo

Traction Control System (TCS)

- What is TCS?
  - Prevent the wheels from loss of traction (when throttle input and engine torque are mismatched to road surface conditions)
- Why is TCS helpful?
  - Losing traction is dangerous
- When is TCS working?
- Where is TCS working?
- Who develops TCS?
- How does TCS work?
  - Monitor potential loss of traction
  - If activated, invoke ABS with other methods
    - Reduce engine torque by limiting throttle application and/or fuel delivery, retard ignition spark, or shut down engine cylinders

Traction Control System (TCS)

- Random stuff
  - Typically, TCS shares the electrohydraulic brake actuator (which does not use the conventional master cylinder and servo) and wheel speed sensors with ABS [Wikipedia]
  - There are instances when traction control is undesirable, such as trying to get a vehicle unstuck in snow or mud [Wikipedia]
  - Video: https://www.youtube.com/watch?v=ZcrA51GPMCQ

Electronic Stability Control (ESC)

- What is ESC?
  - Improve stability by detecting and preventing loss of traction
- Why is ESC helpful?
  - Losing traction (steering control) is dangerous
- When is ESC working?
- Where is ESC working?
- Who develops ESC?
- How does ESC work?
  - Detect loss of traction (steering control)
  - Apply the brakes to help "steer" the vehicle
    - Braking is automatically applied to wheels individually
    - Some ESC systems also reduce engine power until control is regained

Electronic Stability Control (ESC)

- Random stuff
  - ESC has been mandatory in new cars in the U.S and the European Union since 2012 and 2014, respectively [Wikipedia]
  - Video: https://www.youtube.com/watch?v=MCRLKRluk1w

Collision Avoidance System

- What is a collision avoidance system?
  - Brake the vehicle when there is a collision risk
- Why is a collision avoidance system helpful?
  - Avoid a collision
- When is a collision avoidance system working?
- Where is a collision avoidance system working?
- Who develops a collision avoidance system?
- How does a collision avoidance system work?
  - Sense the distance from the vehicle ahead (also consider the speed itself)
    - On-board sensors?
  - Decide if it is going to have a collision
  - Brake if needed

Collision Avoidance System

- Random stuff
  - In March 2016, the manufacturers of 99% of U.S. automobiles had agreed to include automatic emergency braking systems as standard on virtually all new cars sold in the U.S. by 2022 [Wikipedia]
  - Video: https://www.youtube.com/watch?v=ridS396W2BY

Adaptive Cruise Control (ACC)

- What is ACC?
  - Adjust vehicle speed to maintain a safe distance from the vehicle ahead
- Why is ACC helpful?
  - Maintain a safe distance and avoid a collision
- When is ACC working?
- Where is ACC working?
- Who develops ACC?
- How does ACC work?
  - Sense the distance from the vehicle ahead (also consider the speed itself)
    - On-board sensors?
  - Decide if it is safe
  - Maintain a safe distance from the vehicle ahead or brake if needed

Adaptive Cruise Control (ACC)

- Random stuff
  - Full speed range ACC vs. partial cruise control
  - Video: https://www.youtube.com/watch?v=own_VaRZ9M8

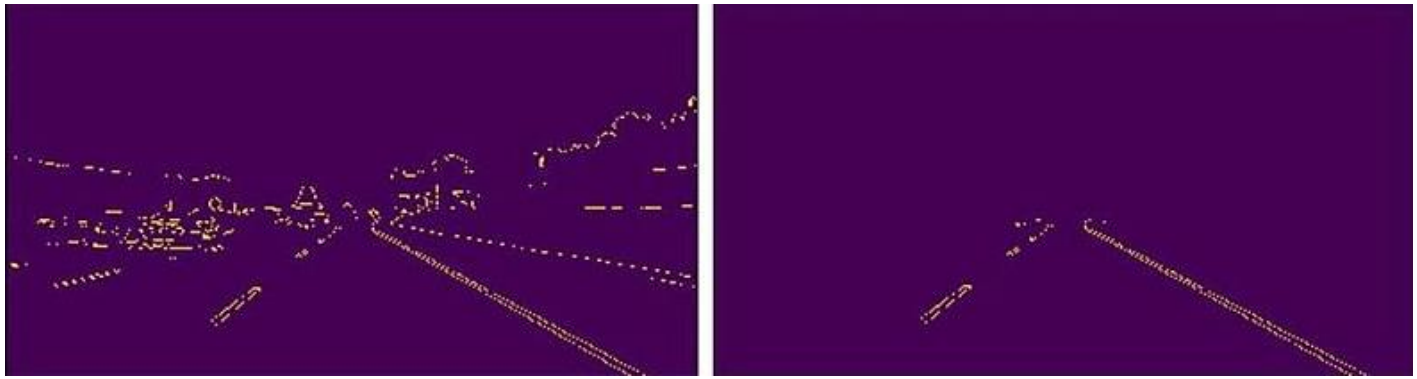
Lane Departure Warning System (LDW) Lane Keeping Assistance (LKA)

- What is LDW/LKA?
  - Warn the driver when the vehicle begins to move out of its lane
- Why is LDW/LKA helpful?
  - Possible scenarios: driver error, distraction, and drowsiness
- When is LDW/LKA working?
- Where is LDW/LKA working?
- Who develops LDW/LKA?
  - Original Equipment Manufactures (OEMs), suppliers, Mobileye
- How does LDW/LKA work?
  - Sense the lanes by lane-detection algorithm
  - Compute the vehicle heading and trajectory and decide if it is safe
  - Warn the driver or take over the control

Lane Departure Warning System (LDW) Lane Keeping Assistance (LKA)

❑ Random stuff

- ➢ Three types [Wikipedia]
  - Warn the driver if the vehicle is leaving its lane
  - Warn the driver and, if no action, take over to keep the vehicle in the lane
  - Take over to keep the vehicle (centered) in the lane and ask the driver to take over in challenging situations
- ➢ LDW/LKA rely on visible lane markings
  - They typically cannot decipher faded, missing, or incorrect lane markings
- ➢ Video: https://www.youtube.com/watch?v=OQkdvi55woA



https://en.wikipedia.org/wiki/Lane_centering

Blind Spot Monitor

- What is a blind spot monitor?
  - Detect other vehicles located to the driver's side and rear
- Why is a blind spot monitor helpful?
  - Safe lane change or backward move
- When is a blind spot monitor working?
- Where is a blind spot monitor working?
- Who develops a blind spot monitor?
  - Original Equipment Manufactures (OEMs), suppliers, aftermarket
- How does a blind spot monitor work?
  - Camera vs. radar
- Random stuff
  - Video: https://www.youtube.com/watch?v=B93tfG4ZydY

Lane Change Assistance System

- What is a lane change assistance system?
  - Detect other vehicles on the target lane and perform lane change
- Why is a lane change assistance system helpful?
  - Safe lane change
- When is a lane change assistance system working?
- Where is a lane change assistance system working?
- Who develops a lane change assistance system?
- How does a lane change assistance system work?
  - Sense objects on the target lane
  - Decide if it is a safe lane change
  - If yes, change to the target lane

Lane Change Assistance System

- Random stuff
  - Video: https://www.youtube.com/watch?v=el4OdwtgzNk
    - https://www.youtube.com/watch?v=el4OdwtgzNk&t=5m25s
    - https://www.youtube.com/watch?v=el4OdwtgzNk&t=6m30s

Surround View System

- What is a surround view system?
  - Provide images of the surround view
- Why is a surround view system helpful?
  - Safe lane change or backward move
- When is a surround view system working?
- Where is a surround view system working?
- Who develops a surround view system?
- How does a surround view system work?
  - Camera

Parking Assistance

- What is parking assistance?
  - Automatic parallel parking
- Why is parking assistance helpful?
  - Prevent parking collision and enhance human comfort
- When is parking assistance working?
- Where is parking assistance working?
- Who develops parking assistance?
- How does parking assistance work?
  - Localize a sufficient parking place along the roadside
  - Attain a start location for the vehicle in front of the parking place
  - Perform a parallel parking maneuver
  - Sensor, camera, and/or radar

Parking Assistance

- Random stuff
  - Video: https://www.youtube.com/watch?v=VOv1IR5rUDw
  - Video: https://www.youtube.com/watch?v=xAQWe0l-Y0I

Automatic High Beams

- What are automatic high beams?
  - Turn forward-oriented lights brighter or dimmer automatically
- Why are automatic high beams helpful?
  - High beams are bad for the visions of opposite-direction drivers
- When are automatic high beams working?
- Where are automatic high beams working?
- Who develops automatic high beams?
- How do automatic high beams work?
  - Use camera to detect light
  - Lower beams if needed

Automatic High Beams

- Random stuff
  - How to warn opposite-direction drivers?
  - Video: https://www.youtube.com/watch?v=BlECPTggvIo
  - Video: https://www.youtube.com/watch?v=Bv46rqY8anM

Driver Monitoring System

- What is a driver monitoring system?
  - Monitor the driver's attentiveness
- Why is a driver monitoring system helpful?
  - Possible scenarios: distraction and drowsiness
- When is a driver monitoring system working?
- Where is a driver monitoring system working?
- Who develops a driver monitoring system?
- How does a driver monitoring system work?
  - Use camera to do eye tracking or monitor the eyelids
  - Warn the driver

Driver Monitoring System

- Random stuff
  - Privacy issue?
  - Video: https://www.youtube.com/watch?v=8Bg7FgDN2R0

Traffic-Sign Recognition

- What is traffic-sign recognition?
  - Recognize traffic signs
- Why is traffic-sign recognition helpful?
  - Remind the driver and support autonomous driving
- When is traffic-sign recognition working?
- Where is traffic-sign recognition working?
- Who develops traffic-sign recognition?
  - So many
- How does traffic-sign recognition work?
  - Machine learning, image recognition
- Random stuff
  - Video: https://www.youtube.com/watch?v=q-_sIfvNx6A

Summary

- Advanced Driver-"Assistance" Systems
  - Fundamental to autonomous driving
  - Not connected so far
- Main objective
  - SAFETY

Q&A