

Introduction to Intelligent Vehicles

[5. Advanced Driver-Assistance Systems]

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Announcement

- Homework 2 due in one week

Revisit Some Concepts

□ Equivalence

➤ Given binary variables a and b

- $a + b = 0 \iff a = 0 \text{ and } b = 0 ?$
- $a + b = 0 \iff ab = 0 ?$
- $a + b > 0 \iff a = 1 \text{ and } b = 1 ?$

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?

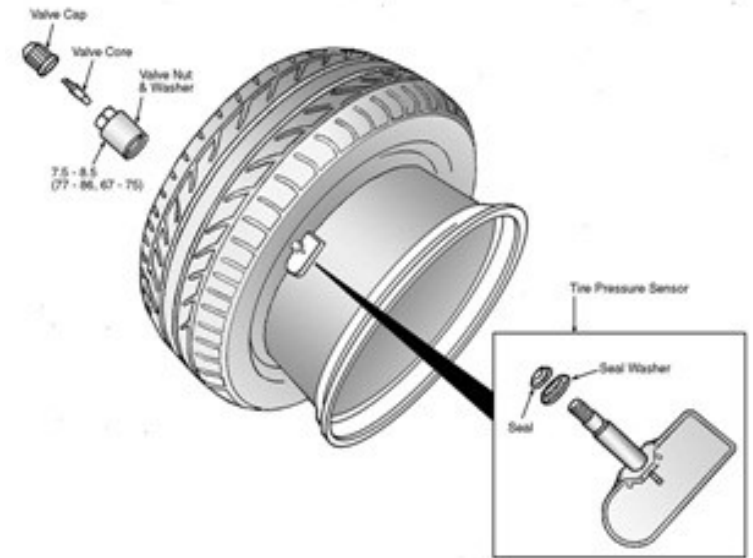
❑ Where is TPMS working?

❑ 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=ru4JlZ-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]
- ESC serves a different purpose from that of ABS or TCS [Wikipedia]
- Video: <https://www.youtube.com/watch?v=MCRLKRIuk1w>
- Video: <https://www.youtube.com/watch?v=Z8KjsjrIGqI>

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 Manufacturers (OEMs), suppliers, Mobileye

❑ How does LDW/LKA work?

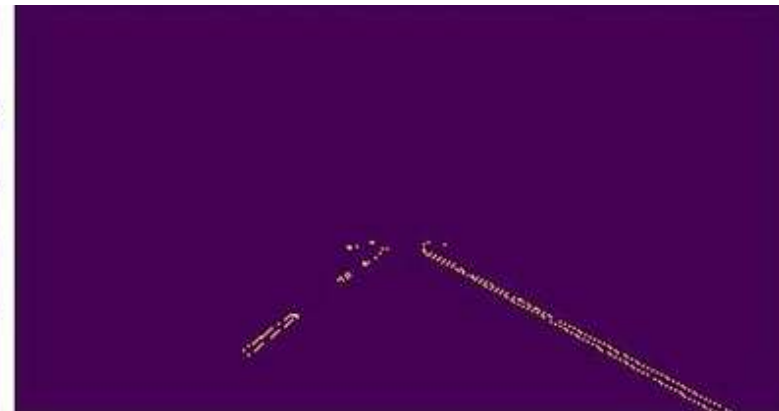
- Sense the lanes by lane-detection algorithm
- Compute the vehicle heading and trajectory and decide if it is safe
- Warn the driver or take over the control

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>
- Video: <https://www.youtube.com/watch?v=pJg7sgf6VfM>



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

□ Random stuff

➤ Video: <https://www.youtube.com/watch?v=el4OdwtgzNk>

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=BlECPTggvlo>
- 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

☐ Random stuff

- Privacy issue?

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

Summary

❑ Advanced Driver-"Assistance" Systems

- Fundamental to autonomous driving
- Not connected so far

❑ Main objective

- SAFETY

Q&A