DEFINITION 5.1: Advanced driver assistance systems are a set of safety systems that are designed to work together to automate and enhance vehicle safety by warning and alerting the driver to potential danger, problem, or collisions.
ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS)

- **Level 1**: Driver assistance
  - Everything on
  - ACC (braking)
  - Lane keeping
  - Auto emergency
  - Braking
  - Parallel park assist
  - 2000

- **Level 2**: Partial automation
  - Feet off
  - ACC (steering)
  - Lane changing
  - Traffic jam assist
  - Overtaking assist
  - 2013

- **Level 3**: Conditional automation
  - Hands off
  - Highway driving (80 km/h)
  - Driver initiated lane change
  - Automated valet parking
  - Traffic jam chauffeur
  - 2018

- **Level 4**: High automation
  - Eyes off
  - Highway driving (160 km/h)
  - Automated lane change
  - Cruising chauffeur
  - Free drive
  - 2024

- **Level 5**: Full automation
  - Mind off
  - Robo-taxi
  - Autonomous shuttle
  - All driving conditions
  - 2027-2030

Autonomy levels according to SAE J3016 (© ARM)

Car technology has improved which enabled more research into the safety systems and direct support to the driver.

Impact:
- Increase the traffic safety
- Traffic efficiency
- Improve sustainability of the vehicles.
ADVANCED DRIVER ASSISTANCE SYSTEM
(TECHNOLOGY)

**RADAR:**
- Provides:
  - Precise Distance measurement
  - Longitudinal Velocity Measurement
- Robust against bad weather
- Good performance during the night
- Not good resolution in lateral and elevation

**CAMERA:**
- Provides:
  - Specific object detection and recognition
  - Good resolution in lateral and elevation
- Absence of velocity measurement
- Not good performance during the night
- Not robust to weather conditions

**LIDAR:**
- Provides:
  - Precise Distance measurement
  - Longitudinal Velocity Measurement
  - Good performance during the night
- Not robust to weather conditions
- Bad resolution in lateral and elevation
ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS)

Sensors
- Lidar
- Camera
- Radar
- Ultrasonic
- V2X
- Acceleration, Speed, Rotation
- GPS

Brain
- [ADVANCED ALGORITHMS]
  FUSION
  MOTION PLANNING
  WARNING
  ETC

Action
- Breaking
- Accelerating
- Maneuvering
- ...

[VEHICLE] DYNAMICS/CONTROL

SIGHT

COM

VEHICLE STATE
ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS)

Sensors
- Lidar
- Camera
- Radar
- Ultrasonic
- V2X
- Acceleration, Speed, Rotation
- GPS

Brain
Sensor hybrid fusion

[ADVANCED ALGORITHMS]
FUSION
MOTION PLANNING
WARNING
ETC

Action
- Breaking
- Accelerating
- Maneuvering

[VEHICLE] DYNAMICS/CONTROL
ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS)

Centralized Approach for data processing and fusion

Sensors
- Lidar
- Camera
- Radar
- Ultrasonic
- V2X

Vehicle State
- Acceleration, Speed, Rotation
- GPS

Sight

Com

Brain

Sensor hybrid fusion

[ADVANCED ALGORITHMS]
FUSION
MOTION PLANNING
WARNING
ETC

Processed Data

Processor

Action
- Breaking
- Accelerating
- Maneuvering

Vehicle Dynamics/Control

[VEHICLE] DYNAMICS/CONTROL
ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS)

Sensors
- Lidar
- Camera
- Radar
- Ultrasonic
- V2X
- Acceleration, Speed, Rotation
- GPS

Brain
- Late fusion
- [ADVANCED ALGORITHMS] FUSION MOTION PLANNING WARNING ETC

Action
- Breaking
- Accelerating
- Maneuvering
- ...
ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS)

Distributed Approach for data processing and fusion

**Sensors**
- Lidar
- Camera
- Radar
- Ultrasonic
- V2X
- Acceleration, Speed, Rotation
- GPS

**Brain**
- Late fusion

- [ADVANCED ALGORITHMS]
  - FUSION
  - MOTION PLANNING
  - WARNING
  - ETC

**Action**
- Breaking
- Accelerating
- Maneuvering

...
ADVANCED DRIVER ASSISTANCE SYSTEM
(Technology)
ADVANCED DRIVER ASSISTANCE SYSTEM
(ADAPTIVE CRUISE CONTROL)

DESCRIPTION 5.1:
The adoptive cruise control is a similar system to cruise control that allows you to fix the speed without pushing the throttle except the adaptive version automatically slow the speed when a vehicle is detected at the front and engage back to the set speed when there is no vehicle at the front.
ADVANCED DRIVER ASSISTANCE SYSTEM
(ADAPTIVE CUISE CONTROL)

System Analysis:

Supporting Task

<table>
<thead>
<tr>
<th>Task</th>
<th>Sub Tasks</th>
<th>Supporting Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilization</td>
<td>Longitudinal</td>
<td>Throttle Control, Brake Control, Gear Control</td>
</tr>
<tr>
<td>Maneuvering</td>
<td>External</td>
<td>Traffic situation-vehicles, Position-speed</td>
</tr>
</tbody>
</table>
## ADVANCED DRIVER ASSISTANCE SYSTEM
### (ADAPTIVE CUISE CONTROL)

### System Analysis:

#### Function Analysis

<table>
<thead>
<tr>
<th>Main Function</th>
<th>Sub Function</th>
</tr>
</thead>
</table>
| Monitor & maintain longitudinal position | Scan road  
Detect vehicle  
Determine Vehicle speed  
Determine local speed  
Calculate braking time  
Calculate following distance |
| Interact with driver                | Provide output  
Acquire input                                         |
| Intervene                           | Apply brake  
Apply gear  
Apply throttle                                |
ADVANCED DRIVER ASSISTANCE SYSTEM
(ADAPTIVE CUISE CONTROL)

System Analysis:
### ADVANCED DRIVER ASSISTANCE SYSTEM (ADAPTIVE CRUISE CONTROL)

System Analysis:

#### System Components

<table>
<thead>
<tr>
<th>Function</th>
<th>Component (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning Road</td>
<td>Radar/ Camera/ Lidar</td>
</tr>
<tr>
<td>Detect Vehicles</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>Determine Vehicle Speed</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>Calculate Braking Time</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>Calculate Following Distance</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td></td>
<td><strong>Input/output</strong></td>
</tr>
<tr>
<td></td>
<td><strong>User Interface</strong></td>
</tr>
<tr>
<td>Apply Brake</td>
<td>Engine and brake control system</td>
</tr>
<tr>
<td>Apply Gear</td>
<td>Engine and brake control system</td>
</tr>
<tr>
<td>Apply Throttle</td>
<td>Engine and brake control system</td>
</tr>
<tr>
<td>Determine Local Speed</td>
<td>Interface to speedometer</td>
</tr>
</tbody>
</table>
ADAS

FRONT COLLISION WARNING
ADVANCED DRIVER ASSISTANCE SYSTEM
(FRONT COLLISION WARNINGS)

DESCRIPTION 5.2:
The front collision warnings system or FCW detect the vehicles in front of the driver’s car and alert the driver.
### ADVANCED DRIVER ASSISTANCE SYSTEM
#### (FRONT COLLISION WARNINGS)

**System Analysis:**

#### Supporting Task

<table>
<thead>
<tr>
<th>Task</th>
<th>Sub Tasks</th>
<th>Throttle Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilization</td>
<td>Longitudinal</td>
<td>Brake Control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gear Control</td>
</tr>
<tr>
<td>Maneuvering</td>
<td>External</td>
<td>Traffic situation-Obstacles</td>
</tr>
</tbody>
</table>
### ADVANCED DRIVER ASSISTANCE SYSTEM
(FRONT COLLISION WARNINGS)

System Analysis:

#### Function Analysis

<table>
<thead>
<tr>
<th>Main Function</th>
<th>Sub Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor longitudinal safety</td>
<td>Detect obstacles</td>
</tr>
<tr>
<td></td>
<td>Identify obstacles</td>
</tr>
<tr>
<td>Interact with driver</td>
<td>Provide output</td>
</tr>
<tr>
<td></td>
<td>Acquire input</td>
</tr>
<tr>
<td>Intervene</td>
<td>Apply brake</td>
</tr>
<tr>
<td></td>
<td>Apply gear</td>
</tr>
<tr>
<td></td>
<td>Apply throttle</td>
</tr>
</tbody>
</table>
ADVANCED DRIVER ASSISTANCE SYSTEM
(FRONT COLLISION WARNINGS)

System Analysis:
### ADVANCED DRIVER ASSISTANCE SYSTEM
**FRONT COLLISION WARNINGS**

**System Analysis:**

#### System Components

<table>
<thead>
<tr>
<th>Function</th>
<th>Component (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detect obstacles</td>
<td>Radar/ Camera</td>
</tr>
<tr>
<td>Identify obstacles</td>
<td>Graphics, Central Processing unit</td>
</tr>
<tr>
<td>Input/output</td>
<td>User Interface</td>
</tr>
<tr>
<td>Apply Brake</td>
<td>Engine and brake control system</td>
</tr>
<tr>
<td>Apply Gear</td>
<td>Engine and brake control system</td>
</tr>
<tr>
<td>Apply Throttle</td>
<td>Engine and brake control system</td>
</tr>
</tbody>
</table>
The main objective behind Lane departure warning (LDW) is to make sure that the car is driven between the lanes. In addition, as an extension the system can be upgraded to lane keeping system (LKS) which means the vehicle take control when the warning has been intimated to bring the car back between the lanes.
ADVANCED DRIVER ASSISTANCE SYSTEM
(LANE DEPARTURE WARNING)

System Analysis:

Supporting Task

<table>
<thead>
<tr>
<th>Task</th>
<th>Sub Tasks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilization</td>
<td>Lateral</td>
<td>Steering wheel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brake control</td>
</tr>
<tr>
<td>Maneuvering</td>
<td>External</td>
<td>Position – heading</td>
</tr>
</tbody>
</table>
## System Analysis:

### Function Analysis

<table>
<thead>
<tr>
<th>Main Function</th>
<th>Sub Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor and maintain lateral position</td>
<td>Scan road&lt;br&gt;Detect road marking&lt;br&gt;Predict path&lt;br&gt;Detect deviations&lt;br&gt;Calculate required corrections</td>
</tr>
<tr>
<td>Interact with driver</td>
<td>Provide output&lt;br&gt;Acquire input</td>
</tr>
<tr>
<td>Intervene</td>
<td>Apply brake&lt;br&gt;Apply steering wheel</td>
</tr>
</tbody>
</table>
ADVANCED DRIVER ASSISTANCE SYSTEM
(LANE DEPARTURE WARNING)

System Analysis:
# ADVANCED DRIVER ASSISTANCE SYSTEM

(LANE DEPARTURE WARNING)

## System Analysis:

### System Components

<table>
<thead>
<tr>
<th>Function</th>
<th>Component(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning road</td>
<td>Camera, infra-red sensor, radar</td>
</tr>
<tr>
<td>Detect road marking</td>
<td>Central processing unit</td>
</tr>
<tr>
<td>Predict path</td>
<td>Central processing unit</td>
</tr>
<tr>
<td>Determine deviations</td>
<td>Central processing unit</td>
</tr>
<tr>
<td>Calculate corrections</td>
<td>Central processing unit</td>
</tr>
<tr>
<td>Input/output</td>
<td>User Interface</td>
</tr>
<tr>
<td>Apply Brake</td>
<td>Engine and brake control system</td>
</tr>
<tr>
<td>Apply steering wheel</td>
<td>Engine and brake control system</td>
</tr>
</tbody>
</table>
ADAS
INTELLIGENT SPEED ASSISTANCE
DESCRIPTION 5.4:

Intelligent speed assistance is in charge of warning in case of excess in speed with respect to the speed limit and take action by reduce it.
ADVANCED DRIVER ASSISTANCE SYSTEM
(INTELLIGENT SPEED ASSISTANCE)

System Analysis:

Step 1:
Car’s system acquires the GPS location and map it to the digital map

Step 2:
Car’s system detect the traffic sign and recognise the speed limit.

Step 3:
If the speed is higher than the speed limit the car’s system warns and reduce the speed automatically.
ADVANCED DRIVER ASSISTANCE SYSTEM
(INTELLIGENT SPEED ASSISTANCE)

System Analysis:

Supporting Task

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<th>Sub Tasks</th>
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</tr>
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<tr>
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<td></td>
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<tr>
<td>Maneuvering</td>
<td>External</td>
<td>Position-speed</td>
</tr>
<tr>
<td></td>
<td>Internal</td>
<td>Vehicle status</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traffic rules (speed)</td>
</tr>
</tbody>
</table>

**ADVANCED DRIVER ASSISTANCE SYSTEM**
*(INTELLIGENT SPEED ASSISTANCE)*

System Analysis:

**Function Analysis**

<table>
<thead>
<tr>
<th>Main Function</th>
<th>Sub Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor and maintain speed</td>
<td>Determine current speed</td>
</tr>
<tr>
<td></td>
<td>Determine speed limit</td>
</tr>
<tr>
<td>Interact with driver</td>
<td>Provide output</td>
</tr>
<tr>
<td></td>
<td>Acquire input</td>
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<tr>
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<td>Apply brake</td>
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<td>Apply throttle</td>
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</table>
### System Components

<table>
<thead>
<tr>
<th>Function</th>
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</thead>
<tbody>
<tr>
<td>Determine current speed</td>
<td>Car systems output (speedometer)</td>
</tr>
<tr>
<td>Determine speed limit</td>
<td>Communication devices, car-to-infrastructure</td>
</tr>
<tr>
<td>Input/output</td>
<td>User Interface</td>
</tr>
<tr>
<td>Apply Brake</td>
<td>Engine and brake control system</td>
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</table>
ADAS
PEDESTRIAN DETECTION
Pedestrian detection in ADAS has many roles. The main role alerting the driver when a pedestrian or cyclist is entering the path of the vehicle. Furthermore, some systems apply independently the brakes if needed when the driver is distracted.
System Analysis:

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**ADVANCED DRIVER ASSISTANCE SYSTEM**

**(TECHNOLOGY)**

System Analysis:

**Function Analysis**

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<tr>
<td></td>
<td>Apply throttle</td>
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</table>
ADVANCED DRIVER ASSISTANCE SYSTEM
(TECHNOLOGY)

System Analysis:

DATA AND PREPROCESSING → SEGMENTATION → OBJECT CLASSIFICATION → VERIFICATION & REFINEMENT → TRACKING → ADAS APPLICATION FOR DRIVER INFORMATION AND ACTION

camera pose → regions of interest (ROIs) → labeled ROIs → verified and refined ROIs → speed, direction, etc.
ADAS
PREVENTING DRIVER FATIGUE
Fatigue detection system is built based on usage of camera to detect the driver’s face and analyses the facial movement and identify signs of fatigue such as closed eyes or dropping head to warn the driver with a loud audible alert.
ADVANCED DRIVER ASSISTANCE SYSTEM
(PREVENTING DRIVER FATIGUE)

- FACE DETECTION
- SETTING REGIONS OF INTEREST OR ROI
- DROWSINESS DETECTION
- DISTRACTION DETECTION
- ALARM!
EXAMPLE 5.1:

Vision-based method for detecting driver drowsiness and distraction in driver monitoring system.


Flowchart of the method
THANK YOU FOR YOUR ATTENTION

— Intelligent Transportation Systems - MTAT.08.040 - Lecture 3