Autonomous Vehicles
and Environment Perception

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Hackathon Presentation

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Outline

1. Autonomous Vehicle
2. Environment Perception

Autonomous Vehicle

An Autonomous Vehicle (AV) has an autonomous driver agent for the lateral and/or longitudinal control of the vehicle in some or all driving modes and conditions.

An AV makes use of various sensors for perception of the environment and localization. Lidar, Radar, Sonar, Camera, GPS, IMU (Inertial Measurement Unit), etc. are examples of AV sensors.

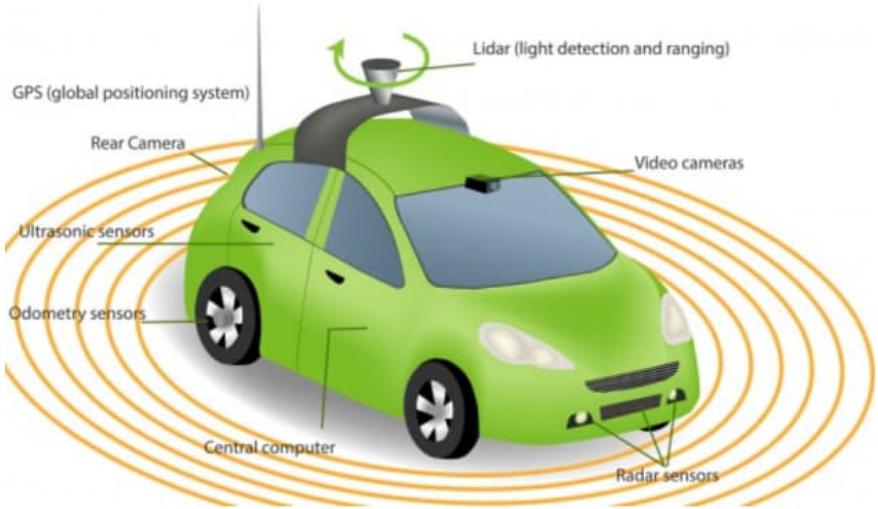

Figure 1: Sensors used in an AV

Autonomy Levels of AV

The level of autonomy an AV possess depends on:

- Autonomous control over lateral and/or longitudinal movement,
- Who performs the object and event detection and response functionality
- The operational design domain of the vehicle

Based on the above mentioned factors, 6 levels of autonomy are defined by the Socitey of Automotive Engineers (SAE) [1]

[1] SAE J3016: *Levels of Driving Automation*

SAE Autonomy Levels

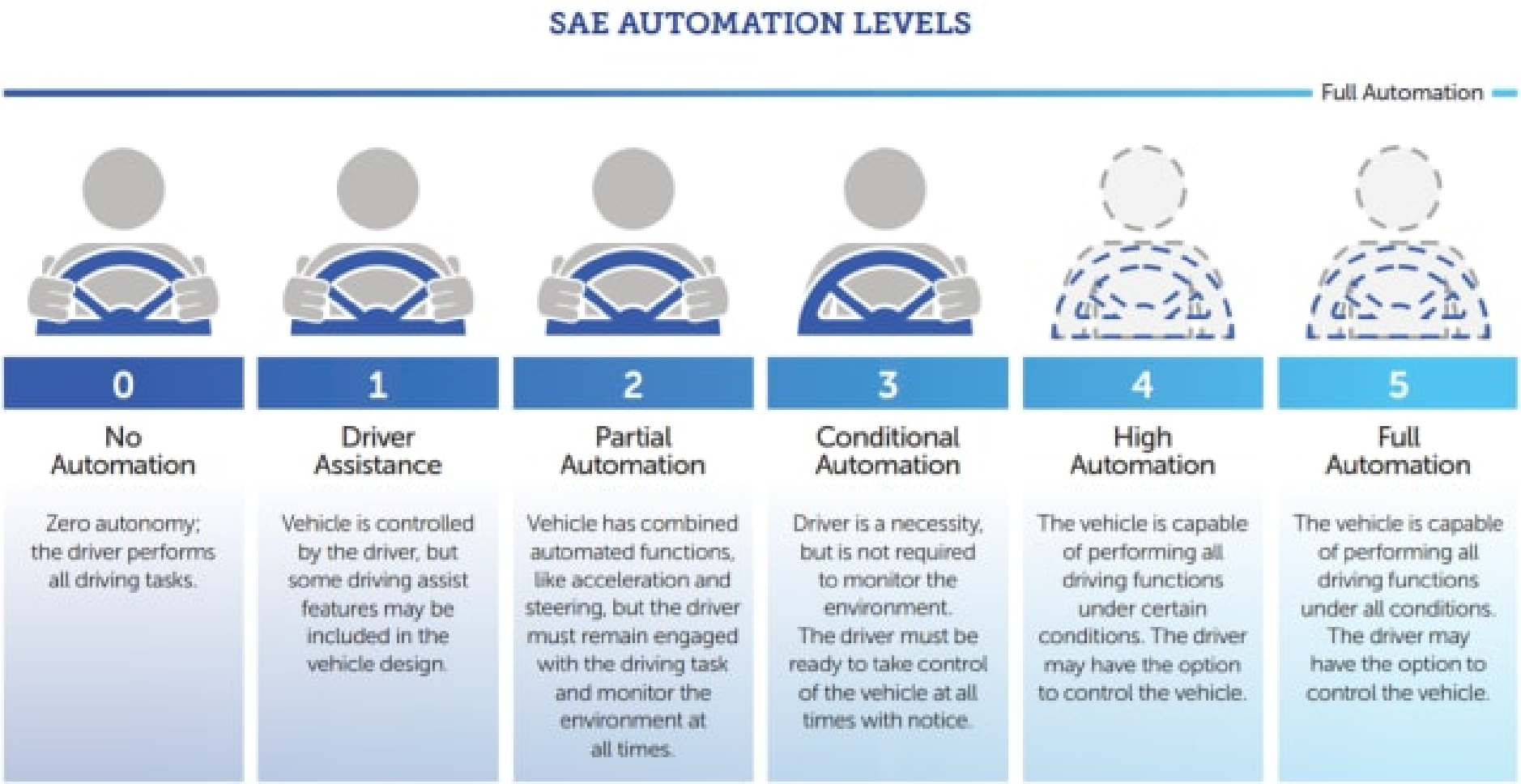

Figure 2: SAE autonomy levels (*image courtesy of SAE*)

AV Classification

Autonomous vehicles are classified on the basis of functionalities performed by the autonomous driving system and the driver present in it. Let us first discuss some key components of AV and some associated terms.

- **Driving Task**: It is a broad terms that includes most of the operations required for autonomous driving. It includes
  - Environment Perception
  - Motion Planning
  - Motion Control
- **Object and Event Detection and Response**: It refers to detection of object and events around the vehicle and reacting to them in appropriate way.
- **Operation Design Domain**: This defines the environment in which the AV is set or designed to operate.

These three factors mentioned above decide the level of autonomy possessed by the AV.

AV Hardware Architecture

Perception Hardware:
This class of hardware gains knowledge of the environment and every object in it. This is required to detect drivable surface and obstacles. These obstacles can be either static or dynamic. Examples of static obstacles are:

- Road and lane markings
- Traffic lights
- Traffic signs
- Road curbs
- Construction signs, obstructions, etc.

Dynamic objects include:

- Other vehicles
- Pedestrians
- Animals

Perception Hardware

The hardware generally required for environment perception include:

- Camera: A passive sensor i.e. requires external light. Key comparison matrix are field of view, resolution and dynamic range.
- LIDAR: An active sensor. Practically unaffected by lighting conditions. Key comparison matrix are resolution and range.
- RADAR: They come in short range and long range. Radars are very robust against weather conditions and precipitation. Key performance matrix are field of view and position and velocity accuracy.
- SONAR: Work on sound waves rather than radio waves as in the case of RADAR. They are very useful for short range obstacle detection such as while parking.

AV Hardware

Other than perception hardware, which are all *exteroceptive* sensors, other class of sensors are also present in AV which are required for detecting ego parameters such as position, velocity, orientation. These are known as *proprioceptive* sensors and include:

- Global Positioning System
- Wheel odometers
- Inertial Measurement Unit device

An AV also requires hardware for computational purposes. Graphical Processing Units (GPU), Field Programming Gate Array (FPGA), Application Specific Integrated Circuits (ASIC) are examples of such hardwares.

AV Software Architecture

The hardware components discussed above pass on a raw data in the form of numbers. For instance, an image returned from a camera is actually a two-dimensional array of pixel values and each pixel value is an array of three values corresponding to the intensities of the three channels present in a colored image.
A possible software architecture of an autonomous vehicle has the following decomposition into the following five parts:

- Environment perception
- Environment mapping
- Motion planning
- Vehicle controller
- System supervisor

1 Autonomous Vehicle

2 Environment Perception

Environment Perception

The objective of environment perception in autonomous vehicles is to detect all the moving and static objects around vehicle that can have influence on its driving operation. It includes

- Lane detection
- Traffic sign detection
- Pedestrian, cyclists, other vehicle detection and tracking.

These detection are made using various perception sensors discussed previously.

Environment Perception

Perception sensors detect objects present around vehicles. The output of these sensors are in the form of numerical values that has to be filtered or transformed and then interpreted to gain information.

For instance, camera captures are generally processed before using them for detection purpose. This include camera calibration, perspective transformation, color channel transformation etc.

Environment Perception

The processed data from perception sensors are then used by Networks of detection networks which are generally deep neural networks pre-trained using real-world data.

Such machine learning and deep learning based detections are used for classification operations such as pedestrian, cyclists detection, semantic segmentation, traffic sign classification, driveable road detection.

Thank You!