Q 1. Explain the different levels of Autonomous Vehicle according to SAE.

Ans:- The Society of Automotive Engineers (SAE) has defined six levels of driving automation for on-road vehicles, ranging from Level 0 (no automation) to Level 5 (full automation). Each level is characterized by the extent of automation and the amount of driver intervention required. Here’s a detailed explanation of each level:

Level 0: No Automation

Description:

- The human driver is responsible for all aspects of driving, including controlling the vehicle's speed, steering, and responding to environmental conditions.

Features:

- No automated driving features.
- Systems such as emergency braking, lane departure warnings, and adaptive cruise control provide alerts or momentary assistance but do not drive the vehicle.

Level 1: Driver Assistance

Description:

- The vehicle can assist with either steering or acceleration/deceleration, but not both simultaneously. The human driver must be engaged and monitor the driving environment at all times.

Features:

- Adaptive Cruise Control (ACC): Automatically adjusts the vehicle's speed to maintain a safe following distance.
- Lane Keeping Assist (LKA): Provides minor steering adjustments to help keep the vehicle within its lane.

Level 2: Partial Automation

Description:

- The vehicle can control both steering and acceleration/deceleration simultaneously, but the human driver must remain engaged, monitor the driving environment, and be ready to take over at any time.

Features:

- Traffic Jam Assist: Helps with steering, braking, and accelerating in heavy traffic conditions.
- Highway Assist: Manages steering, acceleration, and braking on highways under specific conditions.

Level 3: Conditional Automation

Description:

- The vehicle can perform all driving tasks under certain conditions, but the human driver must be available to take over when requested by the system.

Features:

- Traffic Jam Chauffeur: Fully controls the vehicle in traffic jams, allowing the driver to disengage but be ready to resume control when needed.
- Requires driver intervention when the system encounters conditions it cannot handle.

Level 4: High Automation

Description:

- The vehicle can perform all driving tasks and monitor the driving environment in specific conditions or environments (e.g., urban areas, highways). Human intervention is not required within these defined use cases, but it may be necessary outside of them.

Features:

- Autonomous Valet Parking: The vehicle can park itself in a designated parking area without human intervention.
- Urban Driving: Can handle city driving with complex interactions, but only within a geofenced area or under specific conditions.

Level 5: Full Automation

Description:

- The vehicle is capable of performing all driving tasks, under all conditions, and does not require any human intervention.

Features:

- No steering wheel, pedals, or human driver required.
- Can handle all driving scenarios, including extreme weather conditions and complex urban environments.

Summary

- **Level 0 (No Automation)**: Full human control, no automated driving features.
- **Level 1 (Driver Assistance)**: Assistance with either steering or acceleration/deceleration, but not both simultaneously.
- **Level 2 (Partial Automation)**: Simultaneous control of steering and acceleration/deceleration, but the driver must remain engaged.

- **Level 3 (Conditional Automation)**: Full control under certain conditions, but the driver must be ready to take over when requested.
- **Level 4 (High Automation)**: Full control in specific conditions without driver intervention; human input needed outside those conditions.
- **Level 5 (Full Automation)**: Complete autonomy in all driving situations, no human intervention required.

These levels help to standardize the capabilities and limitations of autonomous vehicles, providing a clear framework for development, regulation, and consumer understanding.

Q 2. Create a block diagram for basic Software Decomposition about perception-based architecture.

Ans:- The block diagram for a basic software decomposition in a perception-based architecture for an autonomous vehicle involves breaking down the software system into its primary components and illustrating how these components interact. Here is an outline and description for the block diagram:

Perception-Based Architecture Block Diagram

Components:

1. **Sensors**
   - Camera
   - LiDAR
   - Radar
   - Ultrasonic
   - GPS/IMU
2. **Sensor Fusion**
   - Data Integration
   - Time Synchronization
   - Filtering and Noise Reduction
3. **Perception**
   - Object Detection
   - Object Classification
   - Object Tracking
   - Environment Mapping
   - Localization
4. **Prediction**
   - Path Prediction
   - Behavior Prediction
5. **Planning**
   - Path Planning
   - Motion Planning
6. **Control**
   - Vehicle Control Commands (Steering, Acceleration, Braking)
   - Feedback Loops
7. **Decision Making**

    - Rule-Based Decision Making
    - Machine Learning/AI-Based Decision Making
8. **Communication**
    - Vehicle-to-Vehicle (V2V)
    - Vehicle-to-Infrastructure (V2I)
    - Vehicle-to-Everything (V2X)
9. **Human-Machine Interface (HMI)**
    - User Interface
    - Alerts and Notifications

Block Diagram

Here is a textual representation of how the block diagram would look:

```
[ Sensors ] -> [ Sensor Fusion ] -> [ Perception ] -> [ Prediction ] -> [
Planning ] -> [ Control ]
     |                |                  |                |
|                |
     |                |                  |                |
|                |
     +-> [ Communication ]               |                |
|                |
     +---------------------------------->|                |
|                |
     +--------------------------------------------------->|
|                |
     +-------------------------------------------------------------------
--|                |
     +-------------------------------------------------------------------
------------------>|
     +------------------------------------------------------> [ Decision
Making ] -> [ Control ]
     +------------------------------------------------------------------> [
Human-Machine Interface ]
```

Description:

1. **Sensors**:
    - Collect raw data from the environment. This data includes visual information from cameras, distance measurements from LiDAR and radar, proximity data from ultrasonic sensors, and positional information from GPS/IMU.
2. **Sensor Fusion**:
    - Combines data from various sensors to create a unified, accurate representation of the vehicle's surroundings. This step includes data integration, time synchronization, and filtering to reduce noise and improve accuracy.
3. **Perception**:
    - Processes fused sensor data to detect, classify, and track objects. This includes identifying pedestrians, vehicles, and obstacles, as well as mapping the environment and determining the vehicle's position within it (localization).
4. **Prediction**:
    - Estimates the future positions and behaviors of detected objects based on their current states. This helps in anticipating potential hazards and planning safe maneuvers.
5. **Planning**:

- Determines the optimal path and maneuvers for the vehicle to follow. This includes both high-level path planning (deciding the route) and low-level motion planning (deciding specific actions like lane changes, turns, and stops).

6. **Control**:
    - Executes the planned maneuvers by sending commands to the vehicle's actuators (steering, acceleration, braking). It includes feedback loops to adjust actions based on real-time data and ensure the vehicle follows the planned path accurately.
7. **Decision Making**:
    - Involves making decisions based on rules or machine learning algorithms to handle various driving scenarios, such as yielding to pedestrians, stopping at traffic signals, or merging into traffic.
8. **Communication**:
    - Manages communication with other vehicles (V2V), infrastructure (V2I), and other entities (V2X) to enhance situational awareness and improve decision-making.
9. **Human-Machine Interface (HMI)**:
    - Provides feedback and information to the driver or passengers. This includes displaying the vehicle's status, alerts, and notifications about potential hazards or system actions.

This block diagram and explanation provide a comprehensive overview of the key components in a perception-based architecture for autonomous vehicles, highlighting the flow of data and the interactions between different modules.

```
[ Sensors ] -> [ Sensor Fusion ] -> [ Perception ] -> [ Prediction ] -> [ Planning ] -> [ Control ]

   |          |           |          |         |          |

   |          |           |          |         |          |

   +-> [ Communication ]           |          |         |          |

   +---------------------------------->|          |         |          |

   +---------------------------------------------------|         |          |

   +--------------------------------------------------------------------|          |

   +------------------------------------------------------------------------------------>|

   +-------------------------------------------------> [ Decision Making ] -> [ Control ]

   +------------------------------------------------------------> [ Human-Machine Interface ]
```